TM 5-460

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

CARPENTRY AND BUILDING CONSTRUCTION

Superseded by TM 5-551 B

HEADQUARTERS, DEPARTMENT OF THE ARMY

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TECHNICAL MANUAL No. 5–460

HEADQUARTERS, DEPARTMENT OF THE ARMY
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CARPENTRY AND BUILDING CONSTRUCTION

*** This manual supersedes TM 5–226, 6 May 1943, including C 1, 20 May 1944.**

CHAPTER 1
INTRODUCTION

1. Purpose

This manual provides instruction and guidance for military personnel engaged in, or responsible for, carpentry and building construction. It is applicable both for training and field use.

2. Scope

This manual provides information on the following activities:

a. Carpentry. The functions of and the methods used by the carpenter in maintaining, repairing, and constructing buildings and other wooden structures. Tools not fully discussed are covered in TM 5–461 and the various technical manuals on individual tools.

b. Building Construction. In addition to information on standard theater of operations building construction, this manual gives information on prefabricated buildings, including proper erection, crew organization, erection time rates, and recommended procedures.

CHAPTER 2
LUMBER

3. General

a. Use. The basic construction material in carpentry is lur There are numerous kinds of lumber varying greatly in stru characteristics. For information regarding the timber from lumber is taken, tree classification, and wood structure, see 5–613. An essential part of the training of a carpenter i acquisition of knowledge of wood so that the most suitable rial may be chosen for a particular job. The knowledge of a carpenter includes general information relating to timber and classification, tree and wood structure, and physical characteri This chapter deals with the various types of lumber comm construction carpentry, its application, the standard sizes in which it is available, and the methods of computing lumber quantities in terms of board feet—the units in which it is procured and ordered.

b. Standard Sizes of Bulk Lumber. Lumber is usually sawed into standard size, length, width, and thickness. This permits uniformity in planning structures and in ordering materials. Table I lists the common widths and thicknesses of wood in rough and in dressed dimensions in the United States. Standards have been established for dimension differences between the rough, nominal, or quoted, size of lumber and the standard sizes to which it is actually reduced when dressed. Nominal sizes refer to dimensions prior to surfacing. It is important that these dimension differences be taken into consideration when planning a structure. A good example of the dimension variance may be illustrated by the common 2 by 4. As may be seen in table I, the familiar quoted size "2 by 4" refers to the rough or nominal dimensions but the actual standard size to which the lumber is dressed is 1⅝ by 3⅝ inches.

Table I. Standard Sizes and Quoted Dimensions

Nominal size (in.)	American standard (in.)
1 x 3	25/32 x 2⅝
1 x 4	25/32 x 3⅝
1 x 6	25/32 x 5⅝
1 x 8	25/32 x 7½
1 x 10	25/32 x 9½

Table I. Standard Sizes and Quoted Dimensions—Continued

Nominal size (in.)	American standard (in.)
	$\frac{25}{32}$ x $11\frac{1}{2}$
	$1\frac{5}{8}$ x $3\frac{5}{8}$
	$1\frac{5}{8}$ x $5\frac{5}{8}$
	$1\frac{5}{8}$ x $7\frac{1}{2}$
	$1\frac{5}{8}$ x $9\frac{1}{2}$
	$1\frac{5}{8}$ x $11\frac{1}{2}$
	$2\frac{5}{8}$ x $7\frac{1}{2}$
	$2\frac{5}{8}$ x $9\frac{1}{2}$
	$2\frac{5}{8}$ x $11\frac{1}{2}$
	$3\frac{5}{8}$ x $11\frac{1}{2}$
	$3\frac{5}{8}$ x $15\frac{1}{2}$
	$5\frac{1}{2}$ x $11\frac{1}{2}$
	$5\frac{1}{2}$ x $15\frac{1}{2}$
	$5\frac{1}{2}$ x $17\frac{1}{2}$
	$7\frac{1}{2}$ x $15\frac{1}{2}$
	$7\frac{1}{2}$ x $19\frac{1}{2}$
	$7\frac{1}{2}$ x $23\frac{1}{2}$

c. Grades of Lumber. Lumber as it comes from the sawmill is divided into three main classes: Yard Lumber, Structural Material, and Factory and Shop Lumber. In keeping with the purpose of this manual, only Yard Lumber will be considered. Yard Lumber is manufactured and classified, on a quality basis, into those sizes and shapes, and qualities required for ordinary construction and general building purposes. It is subdivided into classifications of select lumber and common lumber.

(1) *Select lumber.* Select lumber is of good appearance and finishing, and is identified by the following grade names:

(*a*) *Grade A.* Grade A is suitable for natural finishes and practically clear.

(*b*) *Grade B.* Grade B is suitable for natural finishes, of high quality, and generally clear.

(*c*) *Grade C.* Grade C is adapted to high quality paint finishes.

(*d*) *Grade D.* Grade D is suitable for paint finishes between higher finishing grades and common grades, and partaking somewhat, the nature of both.

(2) *Common lumber.* Common lumber is suitable for general construction and utility purposes and is identified by the following grade names:

(*a*) *No. 1 common.* No. 1 common is suitable for use without waste; it is sound and tight-knotted; and it may be considered watertight lumber.

(*b*) *No. 2 common.* No. 2 common is less restricted in quality than No. 1 but of the same general quality. It is used for framing, sheathing, and other structural forms where the stress or strain is not excessive.

(*c*) *No. 3 common.* No. 3 common permits some waste with prevailing grade characteristics larger than in No. 2. It is used for such rough work as footings, guardrails, and rough flooring.

(*d*) *No. 4 common.* No. 4 common permits waste, is of low quality admitting the coarsest features, such as decay and holes. It is used for sheathing, subfloors, and roof boards in the cheaper types of construction, but their most important industrial outlet is for boxes and crates.

(*e*) *No. 5 Common.* No. 5 common is not produced in some species. The only requirement is that it must be usable. It is used for boxes, crates, and dunnage.

4. Types and Standard Sizes of Lumber

a. Framing Lumber. The frame of a building consists of the wooden form constructed to support the finished members of the structure. It includes such items as posts, girders (beams), joists, subfloor, sole plates, girts, knee braces, and rafters. Soft woods are usually used for lightwood framing and all other aspects of construction carpentry considered in this manual. One of the classifications of soft wood lumber cut to standard sizes is called yard lumber and is manufactured for general building purposes. It is cut into those standard sizes required for light framing, including 2 by 4's, 2 by 6's, 2 by 8's, 2 by 10's, 2 by 12's, and all other sizes required for framework, with the exception of those sizes classed as structural lumber: that is, 5 inches and thicker in least dimensions. Although No. 1 to No. 3 common are used for framing, No. 2 common is most often used and is therefore most often stocked and available in retail lumber yards in the common sizes used for various framing members. However, the size of lumber required for any specific structural member will, of course, vary with the design of the building (light frame, heavy frame) and the design of the particular member (beams or girders, for example, may be made from single pieces of structural timber, or built up as required). When lumber requirements are specified in a materials list (table II), the symbols listed under the column "Type (or dressed)" indicate the number of surfaces or edges of the lumber which have been planed. *S1S,* indicates that the piece has been surfaced on one side; *S2S,* surfaced on two sides; *S1E* surfaced one edge; *S2E* surfaced

on two edges; *S1S1E, S1S2E, S2S1E* or *S4S* indicates combinations of surfaced edges and sides.

Table II. Typical Materials List

Item	Type (or dressed)	Quantity[1]	Size	Description
Plates				
Studs				
Headers				
Sill	S4S	250′	2″ x 6″	
Rafters	S4S	250′	2″ x 6″	
Jacks	----------	2	------------	Adjustable
Tarpaulin	----------	1	32′ x 18′	
Sheathing	S4S	600′	1″ x 6″	
Rake board	----------	28′	1¼″ x 4″	
Fascia	----------	30′	1″ x 4″	
Plancier	----------	30′	1″ x 6″	
Bed molding	----------	30′	2″	
Window frame	----------	1	2′–0″ x 2′–0″	Packaged
Window frames	----------	2	3′–0″ x 3′–0″	Packaged
Building paper	15 lb	600 sq ft.	36″	
Shingles	strip	1½ sq ft.	36″	Asphalt
Flashing	16 oz.	30 sq. ft.	------------	Copper
Siding	Bevel	270 sq ft.	10″	

Nailing—8d, 10d, 16d, common 3d copper roofing nails, and lead plugs

[1] Quantities listed in feet include 10 percent allowance for waste.

b. Sheathing and Siding Lumber. The exterior walls of a frame structure usually consist of three layers: sheathing, building paper, and siding. Sheathing lumber is 1 by 6 or 1 by 8 inches No. 1, No. 2, or No. 3 common soft wood, but No. 2 is most often used. It may be plain, tongued and grooved, or ship lapped. Siding lumber may be B and Better, C, D, No. 1 or No. 2 grade and varies in size from ½ by 4 to 1 by 12. C grade is most often used. The two principal types of siding lumber are bevel and drop. Plain or clapboard siding is often used but has a tendency to warp and separate. For standard sizes in siding lumber, see figure 1. Siding is usually procured in bundles consisting of a given number of square feet per bundle. For further discussion see paragraphs 60 and 62.

c. Bills of Materials. A bill of materials is a tabulated list of the material requirements of a structure. Such a bill includes the quantity, size, and purpose of all items needed for the construction. The items listed include lumber, hardware, nails, sashes, doors, brick, cement, lime, paint, plaster, and fixtures. In making out a bill of materials, first the names of the various members in the structure are listed. Their dimensions are taken from the drawing or blue print and the quantity of each piece is determined. Finally,

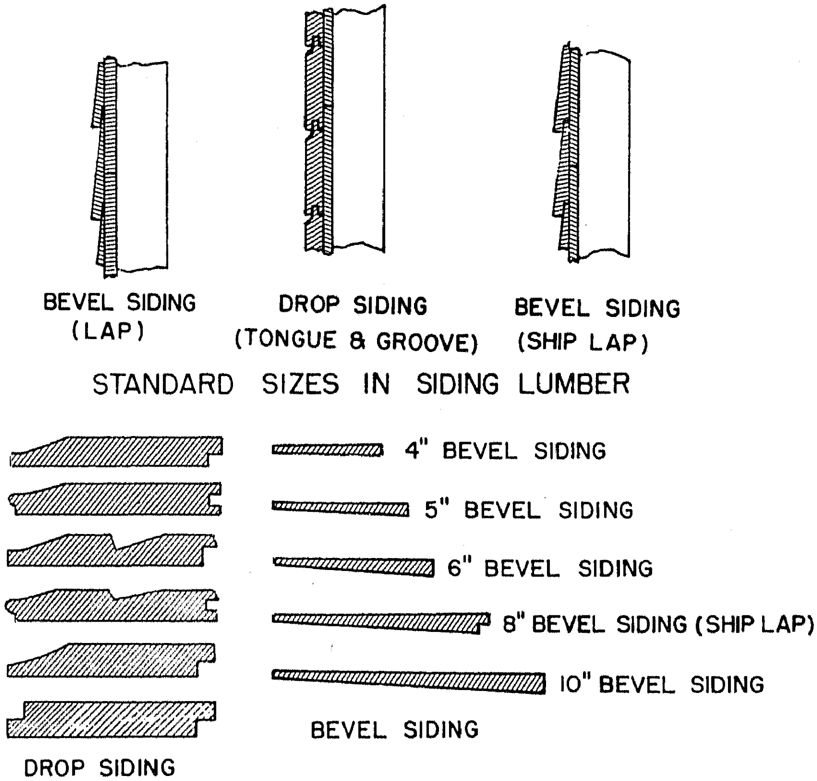


Figure 1. Types of siding.

all pieces of similar size are listed together and an estimate is made of such items as nails and screws.

5. Computation of Board Feet

a. General. Sizes of soft wood or building construction lumber have been standardized for convenience in ordering and handling. Building materials sizes run 8, 10, 12, 14, 16, 18, and 20 feet in length, 2, 4, 6, 8, 10, and 12 inches in width, and 1, 2, and 4 inches in thickness. The actual width and thickness of dressed lumber are considerably less than the standard, or nominal, width and thickness. For the relative differences between standard, or nominal, and actual sizes of construction lumber, see table I. Hard woods, which have no standard lengths or widths, run $\frac{1}{4}$, $\frac{1}{2}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, and 4 inches in thickness. Plywoods run from 4 feet in width to 8 feet in length, and vary in thickness from $\frac{1}{8}$ to 1 inch. Stock panels are usually available in width of 48 inches and lengths varying in multiples of 16 inches up to 8 feet. Panel lengths run in 16-inch multiples because the accepted spacing for studs and joists is 16 inches. The amount of lumber required is measured in

board feet. A board foot is a unit of measure representing a piece of lumber having a flat surface area of 1 square foot and a thickness of 1 inch actual or nominal size. The number of board feet in a piece of lumber can be computed by the arithmetic method or by the tabular method.

b. Arithmetic Method for Computing Board Feet. In order to determine the number of board feet in one or more pieces of lumber, the following formula is used:

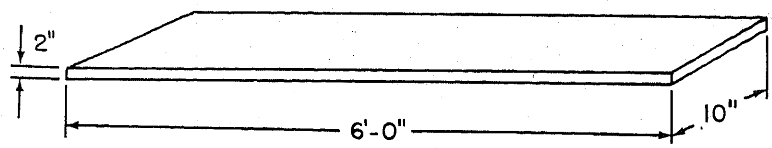
$$\frac{\text{Pieces} \times \text{Thickness in inches} \times \text{Width in inches} \times \text{Length in feet}}{12}$$

Example 1: Find the number of board feet in a piece of lumber 2 inches thick, 10 inches wide and 6 feet long (fig. 2).

$$\frac{1 \times 2 \times 10 \times 6}{12} = 10 \text{ Bd Ft}$$

Example 2: Find the number of board feet in 10 pieces of lumber 2 inches thick, 10 inches wide and 6 feet long.

$$\frac{10 \times 2 \times 10 \times 6}{12} = 100 \text{ Bd Ft}$$



$$\frac{\text{PIECES X THICKNESS (INCHES) X WIDTH (INCHES) X LENGTH (FEET)}}{12} = \text{BD-FT}$$

$$\frac{1 \text{ X } 2 \text{ X } 10 \text{ X } 6}{12} = 10 \text{ BD-FT}$$

Figure 2. Board feet computation.

If all three dimensions are expressed in inches, the same formula applies except the divisor is changed to 144.

Example: Find the number of board feet in a piece of lumber 2 inches thick, 10 inches wide and 18 inches long.

$$\frac{1 \times 2 \times 10 \times 18}{144} = 2\tfrac{1}{2} \text{ Bd Ft}$$

c. Tabular Method of Computing Board Feet With Use of a Framing Square (fig. 3). The standard essex board measure table (fig. 3), appearing on the back of the blade of the framing square, is a quick and convenient aid in computing board feet. In using the board measure table, all computations are made on the basis of 1-inch thickness. The inch markings along the outer edge of the blade represent the width of a board 1 inch thick. The third

dimension, length, is provided in the vertical column of figures under the 12-inch mark. To compute the number of board feet in a piece of lumber 4 inches thick, 8 inches wide, and 14 feet long, find the number 14 in the vertical column under the 12-inch mark. Then follow the guideline under the figure 14 laterally across the blade until it reaches the figure on that line directly under the inch mark corresponding to the width of the piece. Under the 8-inch mark on the guideline indicated by the 14, the figures 9 and 4 appear. The figure to the left of the vertical line represents feet an on the right represents inches. In this case, these figures that there are 9 and 4/12 or 9½ board feet in a piece of 14 feet long, 8 inches wide, and 1 inch thick. To convert thi to the proper number of board feet in a piece of the sam and length but 4 inches thick, as is the piece we are concern simply multiply the proper answer for a board 1 inch thic The proper number in this case is 37½ board feet.

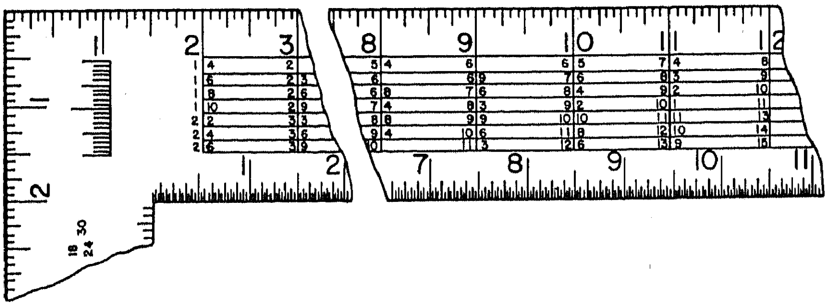


Figure 3. Essex board measure table.

d. Rapid Estimation of Board Feet by Use of Tables. Rapid estimation of board feet can be made by the use of table III or table IV.

Table III. Rapid Calculation of Board Measure

Width	Thickness	Board feet
3″	1″ or less	¼ of the length
4″	1″ or less	⅓ of the length
6″	1″ or less	½ of the length
9″	1″ or less	¾ of the length
12″	1″ or less	Same as the length
15″	1″ or less	1¼ of the length

Table IV. Board Fee.

Nominal size (in.)	Actual length in feet								
	8	10	12	14	16	18	20	22	24
1 x 2	------------	1⅔	2	2⅓	2⅔	3	3⅓	3⅔	4
1 x 3	------------	2½	3	3½	4	4½	5	5½	6
1 x 4	2⅔	3⅓	4	4⅔	5⅓	6	6⅔	7⅓	8
1 x 5	------------	4⅙	5	5⅚	6⅔	7½	8⅓	9⅙	10
1 x 6	4	5	6	7	8	9	10	11	12
1 x 7	------------	5⅚	7	8⅙	9⅓	10½	11⅔	12⅚	14
1 x 8	5⅓	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
1 x 10	6⅔	8⅓	10	11⅔	13⅓	15	16⅔	18⅓	20
1 x 12	8	10	12	14	16	18	20	22	24
1¼ x 4	------------	4⅙	5	5⅚	6⅔	7½	8⅓	9⅙	10
1¼ x 6	------------	6¼	7½	8¾	10	11¼	12½	13¾	15
1¼ x 8	------------	8⅓	10	11⅔	13⅓	15	16⅔	18⅓	20
1¼ x 10	------------	10 5/12	12½	14 7/12	16⅔	18¾	20⅚	22 11/12	25
1¼ x 12	------------	12½	15	17½	20	22½	25	27½	30
1½ x 4	4	5	6	7	8	9	10	11	12
1½ x 6	6	7½	9	10½	12	13½	15	16½	18
1½ x 8	8	10	12	14	16	18	20	22	24
1½ x 10	10	12½	15	17½	20	22½	25	27½	30
1½ x 12	12	15	18	21	24	27	30	33	36
2 x 4	5⅓	6⅔	8	9⅓	10⅔	12	13⅓	14⅔	16
2 x 6	8	10	12	14	16	18	20	22	24
2 x 8	10⅔	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
2 x 10	13⅓	16⅔	20	23⅓	26⅔	30	33⅓	36⅔	40
2 x 12	16	20	24	28	32	36	40	44	48
3 x 6	12	15	18	21	24	27	30	33	36
3 x 8	16	20	24	28	32	36	40	44	48

3 x 10	20	25	30	35	40	45	50	55	60
3 x 12	24	30	36	42	48	54	60	66	72
4 x 4	10⅔	13⅓	16	18⅔	21⅓	24	26⅔	29⅓	32
4 x 6	16	20	24	28	32	36	40	44	48
4 x 8	21⅓	26⅔	32	37⅓	42⅔	48	53⅓	58⅔	64
4 x 10	26⅔	33⅓	40	46⅔	53⅓	60	66⅔	73⅓	80
4 x 12	32	40	48	56	64	72	80	88	96

CHAPTER 3
JOINTS, SPLICES, AND METHODS OF FASTENING

Section I. JOINTS

6. General

a. A structure is no stronger than its weakest point. The weak points in a structure usually occur where there are connections between materials. The existence of such weak points is generally an indication of faulty workmanship, since connections can be made so that the strength of the structure at these points is unimpaired.

b. The connections between pieces of wood in carpentry are simple. Made properly, they are strong. The Army carpenter must learn to make these connections accurately and quickly.

...nber are classified either ...s between two pieces of ... Splices are connections ...o pieces of timber which extend in the same line.

Types of Joints
(fig. 4)

The most commonly used types of joints used in carpentry are the butt and lap joint. The butt joint is constructed by placing the end of one board on another board in such a manner that the boards are at an angle (usually a right angle), forming a corner. The lap joint is constructed by overlapping two pieces of wood and securing them to form a joint, or by cutting away corresponding portions (usually half) in equal lengths from the thickness of two boards and then joining them in such a manner that the cutaway portions overlap and form a corner. The various types of joints are discussed in the following paragraphs.

8. Butt Joints

a. Straight Butt Joint. The straight butt joint is formed by bringing the square-cut end of one board against the square face of another (1 and 2, fig. 4). The butt end of one board should be square and the face of the other smooth so that the pieces fit properly and are perpendicular to each other. Nails or screws are used

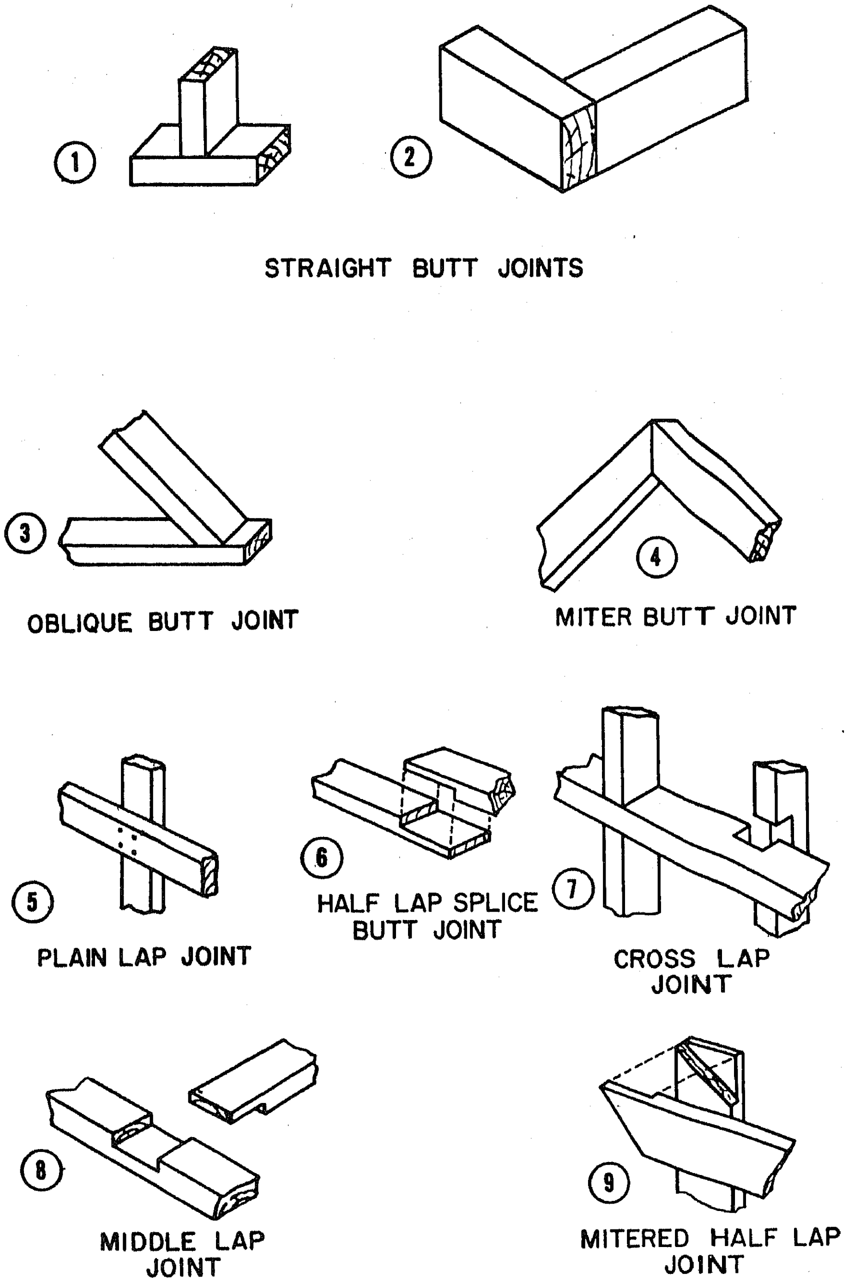


Figure 4. Butt and lap joints.

to hold the two pieces together. Properly selected screws will hold such a joint securely. However, for framing, butt joints are secured by 8- or 10-penny nails which are toenailed to strengthen the joint. Toenailing is done by driving the nail diagonally through both pieces. End grain is the weakest part of a piece of wood when used in joint connections. Since a butt joint connection is made at either one or two end-grain parts, the connection will be no stronger than the characteristics of the end-grain parts. A butt joint is therefore the weakest type of joint. This is especially true if the joint is of two pieces of wood only.

b. Oblique Butt Joint. The oblique butt joint is formed by bringing the end of one board, cut on the oblique to form the desired angle against the face of another board with which it is to be joined (3, fig. 4). Bracing is a typical application for this joint. This joint should not be used where great strength is required. The strength of the joint depends upon the nailing; the size of the nails used depends entirely upon the size of the timber. Nails should be toenailed as in the case of the straight butt joint and the use of too many nails should be avoided.

c. Miter Butt Joint. The miter butt joint is formed by bringing the mitered ends of two boards together to form the desired angle (4, fig. 4). The miter butt joint is usually used at corners where the straight butt joint is not satisfactory. To make a miter joint, the angle of cut is the same for both pieces. To form a right-angle miter joint (the most commonly used miter joint), each piece is cut [illegible] when the pieces are joined they will form a [illegible] angle. The miter joint is used extensively in framing but is a weak joint and is not to be used where strength of joint is [i]mportant factor.

9. Lap Joints

a. Plain Lap Joint. The plain lap joint is formed by laying one board over another and securing the two by means of screws or nails (5, fig. 4). This is the simplest and most often used method of joining in framing and construction. The joint constructed in this manner is as strong as the fasteners and material used in its support.

b. Half-Lap Splice Joint. The half-lap splice joint is constructed by cutting away portions (usually half) in equal lengths from the thickness of two boards and joining them in such a manner that the cut-away portions overlap in a complementary manner to form the joint (6, fig. 4). The half-lap is a relatively strong, easily made joint. Overlapping surfaces must fit snugly and smoothly. Saw on the waste side of the gage line when cutting out the laps to avoid

cutting laps oversize by the thickness of the kerf. Several useful variations of the half-lap are: cross lap (7, fig. 4), middle lap (8, fig. 4), and mitered half-lap (9, fig. 4).

10. Other Useful Joints
(fig. 5)

a. Dado and Rabbet. The dado is a rectangular, square-bottomed groove cut in wood, and a rabbet is a corner cut out of an edge of a piece of wood. Both the dado and the rabbet are used to form

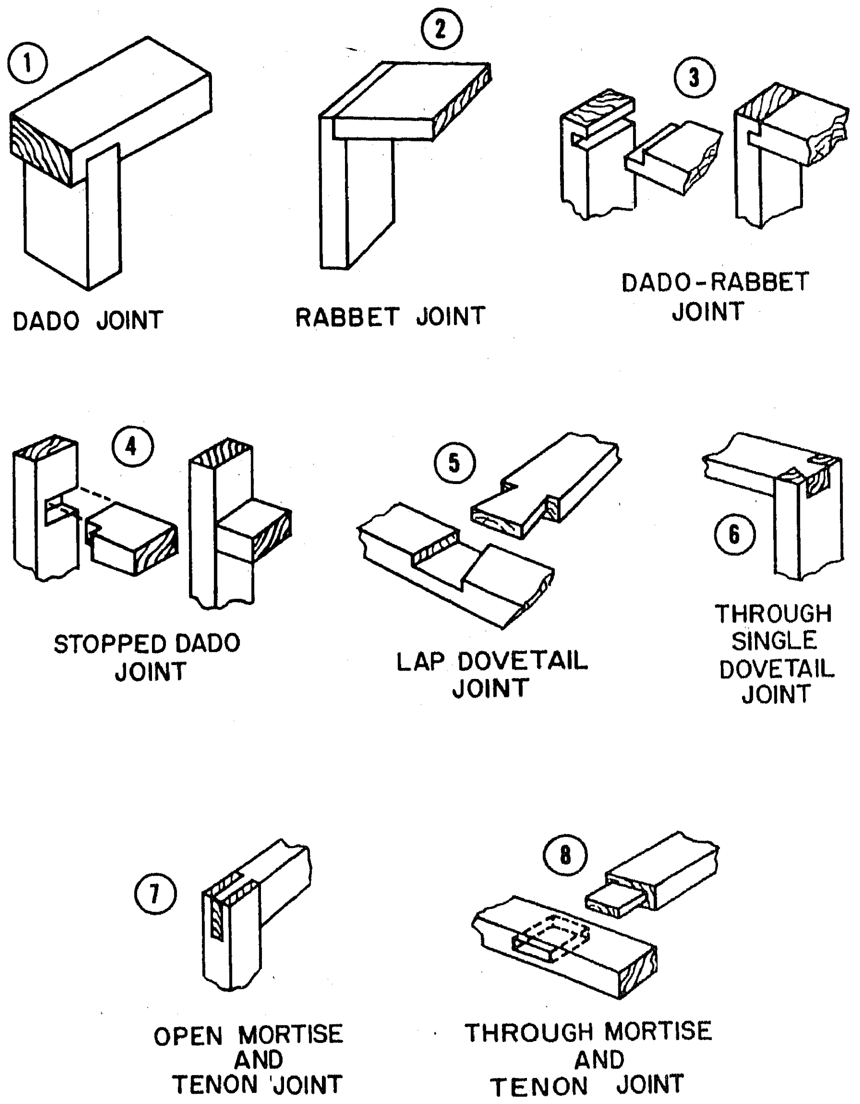


Figure 5. Dado, rabbet, dovetail, and mortise and tenon joints.

o joint (1, fig. 5), rabbet joint (2, fig. 5), 5), and stopped dado (4, fig. 5).

ion. Locked joints give added and workmanship and are not quired of the joint. The most ail (5, fig. 5), through single tenon (7, fig. 5), and through

LICES

more pieces of timber as strong as a single ll be as strong as the is determined by the ubjected to the stress ected to direct longi- or in exerting pres- ession. Timbers sub- when used as trusses, resist tension (2, fig. supports require splices designed ices efficient in resisting compres- are usually worthless for tension or bending; therefore, splices should be made to meet the conditions for which they are to be used. The carpenter should familiarize himself with each type of splice and should be able to make and apply each properly.

12. Compression Resistant Splices

a. General. Compression resistant splices are designed to sup-

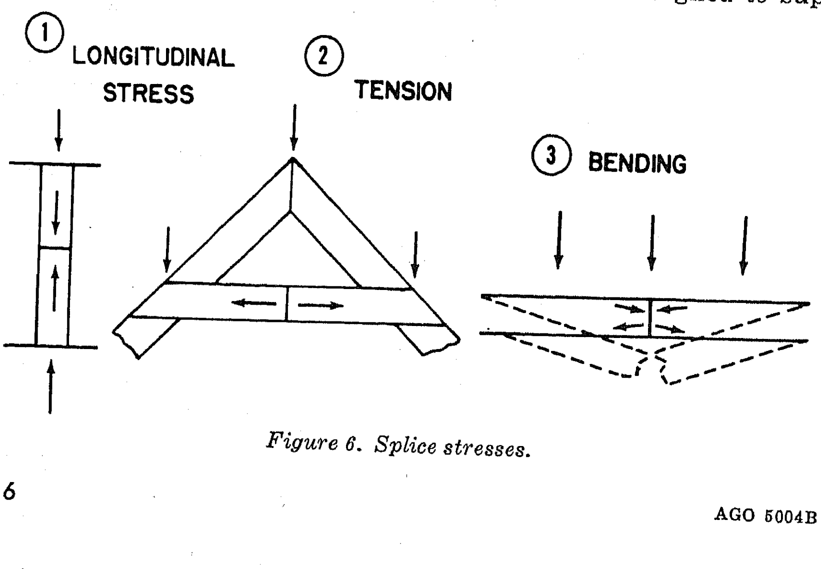


Figure 6. Splice stresses.

port weight or exert pressure and will effectively resist compression stress only. The butt splice and the halved splice are the most common types of compression resistant splices.

b. Butt Splice. The butt splice is constructed by butting the squared ends of two pieces of timber together and securing them in this position by means of two wood or metal pieces fastened on opposite sides of the timber (1 and 2, fig. 7). The two short supporting pieces keep the splice straight and prevent buckling. Metal plates used as supports in constructing a butt splice are called fishplates (1, fig. 7). Wood plates are called scabs (2, fig. 7). Fish plates are fastened in place with bolts or screws. Bolts, nails, corrugated fasteners (par. 20) may be used to secure scabs. nails are used with scabs, they are staggered and driven at

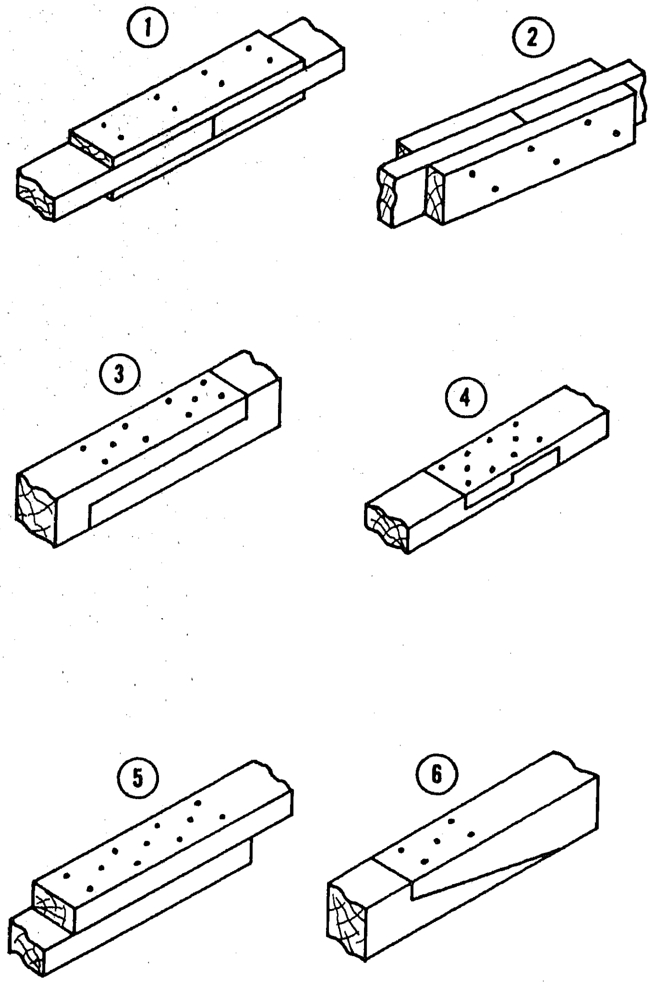


Figure 7. Compression, tension, and bending splices.

angle away from the splice. Too many nails, or nails that are too large, will weaken a splice.

' *Splice.* The halved splice is constructed by cutting hickness of equal lengths from the ends of two pieces itting the complementary tongues or laps together. .. be long enough to have adequate bearing surfaces. ...s may be used to fasten the halved splice (3, fig. 7). to give this type of splice resistance to some tension as mpression, fishplates or scabs may be used as with the lice.

'ension Resistant Splices

General. In tension members such as trusses, braces, and , the joint undergoes stress that is exerted in more than one tion and creates a tension tending to buckle the member in a ctable direction. Tension splices are designed to provide the est practicable number of bearing surfaces and shoulders n the splice to resist the buckling tension.

Square Splice. The square splice is a modification of the com- ion halved splice. Complementary notches are cut in the ies or laps to provide an additional locking shoulder (4, fig. 'he square splice may be fastened with nails or bolts or may eatly strengthened by the use of fishplates or scabs.

Plain Splice. A hasty substitute for the square splice is the plain splice (5, fig. 7). A long overlap of the two pieces is able to provide adequate bearing surface and sufficient room nough fasteners to compensate for the lack of shoulder lock.

Bend Resistant Splices

General. Horizontal timbers supporting weight undergo stress at a splice which results in a compression of the upper part that has a tendency to crush the fibers and in a tension of the lower part that tends to pull the fibers apart. Bend resistant splices are designed to resist both compression and tension; they combine the features of the compression and tension splices.

b. *Construction.* The bend resistant splice is constructed by cutting oblique complementary laps in the ends of two pieces of timber. The upper tongue (bearing surface) is squared to butt against the square of the complementary lap (6, fig. 7) to offer maximum resistance to crushing, and the lower tongue is beveled. A scab or fishplate may be fastened along the bottom of the splice to resist the tendency of the pieces to separate. In any case where it is not desirable to lap or halve the timber ends for a splice subject to tension, a butt joint secured by fishplates may be used.

Section III. METHODS OF FASTENING

15. General

The fasteners used in the theater of operations are made of metal. These may be classified as nails, screws, bolts, driftpins, corrugated fasteners, and timber connectors.

16. Nails

a. General. The standard nail used by the Army carpenter is the wire nail, so called because it is made from steel wire. Ther are many types of nails, all of which are classified according t and form. The wire nail is round-shafted, straight, pointed, may vary in size, weight, size and shape of head, type of point finish. All normal requirements of construction and framing are filled by one of the nail types listed below. There are a few general rules to be followed in the use of nails in carpentry. A nail, whatever the type, should be at least three times as long as the thickness of wood it is intended to hold. Two-thirds of the length of the nail is driven into the second piece for proper anchorage while one-third provides the necessary anchorage of the piece being fastened. Nails should be driven at an angle slightly toward each other and should be carefully placed to provide the greatest holding power. Nails driven with the grain do not hold as well as nails driven across the grain. A few nails of proper type and size, properly placed and properly driven, will hold better than a great many driven close together. Nails can generally be considered the cheapest and easiest fasteners to be applied. In terms of holding power alone, nails provide the least; screws of comparable size provide more, and bolts provide the greatest amount.

b. Types of Nails.

(1) *Common wire nails.* Common wire nails and box nails are the same except that the wire sizes are one or two numbers smaller for a given length of the box nail than they are for the common nail. The common wire nail (1, fig. 8) is used for housing-construction framing. The common wire nail and the box nail are generally used for structural carpentry.

(2) *Finishing nails* (2, fig. 8). The finishing nail is made from finer wire and has a smaller head than the common nail. It may be set below the surface of the wood into which it is driven and will leave only a small hole easily puttied up. It is generally used for interior or exterior finishing work and is used for finished carpentry and cabinetmaking.

(3) *Scaffold or form nails* (3, fig. 8). The scaffold, form, or

staging nail (as it is sometimes called) is made with what
e two heads. The lower head, or shoulder,
ıat the nail may be driven securely home
m holding power while the upper head
he surface of the wood to make its with-
'he reason for this design is that the
; meant to be permanent. It is used in
temporary structures such as scaffold-
and is classified for temporary con-

g. 8). Roofing nails are round-shafted,
galvanized nails of relatively short
·atively large heads. They are designed
ble roofing materials and for resisting
ıre to weather. Several general rules
of roofing nails, especially their use
gles. If shingles or roll roofing is being
'oofing, the roofing nails selected must
gth to go through the old material and
Asphalt roofing material is fastened
sistant nails, never with plain nails.
in the center of the shingle, just above
ts, to avoid buckling.

ails. Nail sizes are designated by the
of the term "penny". This term designates the length of the nail (1 penny, 2 penny, etc.), which is the same for all types. The approximate number of nails per pound, varies according to the type and size. The wire gage number varies according to type. Figure 8 provides the information implicit in the term "penny" for each of the type of nails referenced to in this section. The "d" adjacent to the numbers in the "Size" column is the accepted abbreviation of the word "penny" as used in nail sizing and should be read "2 penny", "3 penny", etc. Table V gives the general size and type of nail preferable for specific applications.

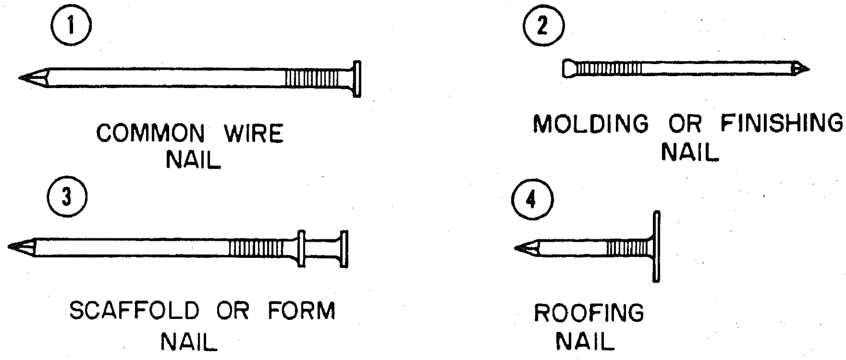
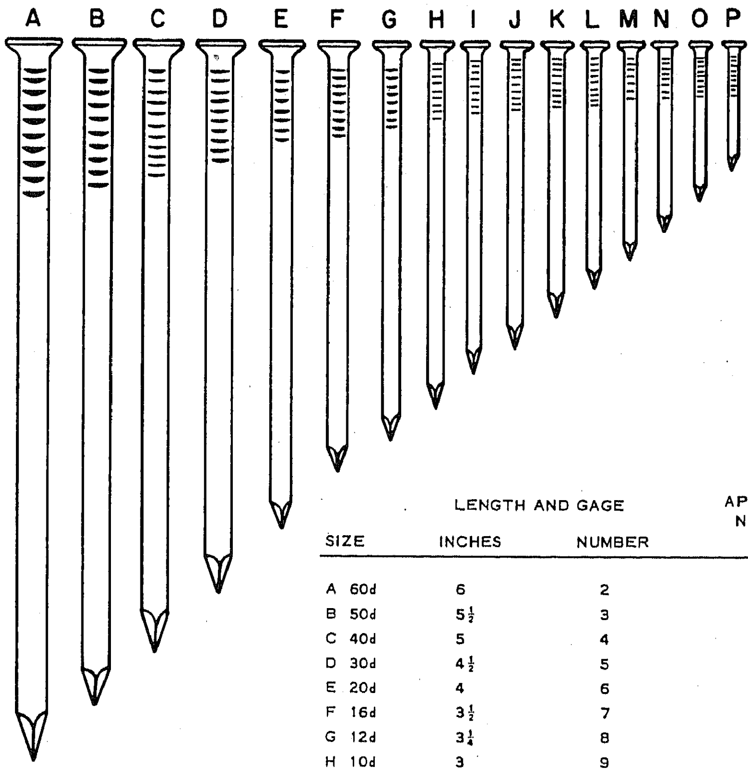


Figure 8. Types of nails and nail sizes.



SIZE		LENGTH AND GAGE INCHES	LENGTH AND GAGE NUMBER	APPROXIMATE NUMBER TO POUND
A	60d	6	2	11
B	50d	5½	3	14
C	40d	5	4	18
D	30d	4½	5	24
E	20d	4	6	31
F	16d	3½	7	49
G	12d	3¼	8	63
H	10d	3	9	69
I	9d	2¾	10¼	96
J	8d	2½	10¼	106
K	7d	2¼	11½	161
L	6d	2	11½	181
M	5d	1¾	12½	271
N	4d	1½	12½	316
O	3d	1¼	14	568
P	2d	1	15	876

Figure 8—Continued.

Table V. Size, Type, and Use of Nails[1]

Size	Lgth (in.)	Diam (in.)	Remarks	Where used
2d	1	.072	Small head	Finish work, shop work.
2d	1	.072	Large flathead	Small timber, wood shingles, lathes.
3d	1¼	.08	Small head	Finish work, shop work.
3d	1¼	.08	Large flathead	Small timber, wood shingles, lathes.
4d	1½	.098	Small head	Finish work, shop work.
4d	1½	.098	Large flathead	Small timber, lathes, shop work.
5d	1¾	.098	Small head	Finish work, shop work.
5d	1¾	.098	Large flathead	Small timber, lathes, shop work.
6d	2	.113	Small head	Finish work, casing, stops, etc., shop work.
6d	2	.113	Large flathead	Small timber, siding, sheathing, etc., shop work.
7d	2¼	.113	Small head	Casing, base, ceiling, stops, etc.
7d	2¼	.113	Large flathead	Sheathing, siding, subflooring, light framing.
8d	2½	.131	Small head	Casing, base, ceiling, wainscot, etc., shop work.
8d	2½	.131	Large flathead	Sheathing, siding, subflooring, light framing, shop work.
8d	1¼	.131	Extra-large flathead	Roll roofing, composition shingles.
9d	2¾	.131	Small head	Casing, base, ceiling, etc.
9d	2¾	.131	Large flathead	Sheathing, siding, subflooring, framing, shop work.
10d	3	.148	Small head	Casing, base, ceiling, etc., shop work.
10d	3	.148	Large flathead	Sheathing, siding, subflooring, framing, shop work.
12d	3¼	.148	Large flathead	Sheathing, subflooring, framing.
16d	3½	.162	Large flathead	Framing, bridges, etc.
20d	4	.192	Large flathead	Framing, bridges, etc.
30d	4½	.207	Large flathead	Heavy framing, bridges, etc.
40d	5	.225	Large flathead	Heavy framing, bridges, etc.
50d	5½	.244	Large flathead	Extra-heavy framing, bridges, etc.
60d	6	.262	Large flathead	Extra-heavy framing, bridges, etc.

[1] This chart applies to wire nails, although it may be used to determine the length of cut nails.

17. Screws

a. General. The use of screws, rather than nails, as fasteners may be dictated by a number of factors. These may include the type of material to be fastened, the requirement for greater holding power than could be obtained by the use of nails, the finished appearance desired, and the fact that the number of fasteners that can be used is limited. The use of screws, rather than nails, is more expensive in terms of time and money but is often necessary to meet requirements for superior results. The main advantages of screws are—they provide more holding power; can be easily tightened to draw the items being fastened secu together; are neater in appearance if properly driven; and be withdrawn without damaging the material. The common screw is usually made of unhardened steel, stainless steel, num, or brass. The steel may be bright finished or blued, or cadmium, or chrome plated. Wood screws are threaded from gimlet point for approximately ⅔ of the length of the screw and are provided with a slotted head designed to be driven by an inserted driver.

b. Types and Uses of Screws.

(1) *Wood screws* (1, fig. 9). Wood screws are designated according to head style. The most common types are: flathead, ovalhead, and roundhead, both in slotted and phillips heads. To prepare wood for receiving the screws, bore a pilot hole the diameter of the screw to be used in the piece of wood that is to be fastened (fig. 10). Then bore a smaller, starter hole in the piece of wood that is to act as anchor or hold the threads of the screw. The starter hole is drilled with a diameter less than that of the screw threads and to a depth ½ or ⅔ the length of the threads to be anchored. The purpose of this careful preparation is to assure accuracy in the placement of the screws, to reduce the possibility of splitting the wood, and to reduce the time and effort required to drive the screw. Properly set slotted and phillips flathead and ovalhead screws are countersunk sufficiently to permit a covering material to be used to cover the head. Slotted roundhead and phillips roundhead screws are not countersunk, but are driven so that the head is firmly flush with the surface of the wood. The slot of the roundhead screw is left parallel with the grain of the wood.

(2) *Lag screws* (2, fig. 9). The proper name for lag screws within the Army supply system is lag bolt, wood screw type. These screws are often required in construction

carpentry. They are longer and much heavier than t
common wood screw and have coarser threads whi
extend from a cone or gimlet point slightly more th
half the length of the screw. Squarehead and hexagc
head lag screws are always externally driven, usua
by means of a wrench. They are used when ordina
wood screws would be too short or too light and spik
would not be strong enough. For sizes of lag screws, s
table VIII. Combined with expansion anchors, they a
used to frame timbers to existing masonry.

(3) *Expansion shields.* Expansion shields, or expansi
anchors as they are sometimes called, are used for i
serting a predrilled hole, usually in masonry, to provi
a gripping base or anchor for a screw, bolt, or n
intended to fasten an item to the surface in which t
hole was bored. The shield may be obtained separat
or may include the screw, bolt, or nail. After the e
pansion shield is inserted in the predrilled hole, t
fastener is driven into the hole in the shield, expandi
the shield and wedging it firmly against the surface
the hole. For additional information, see paragraph 1

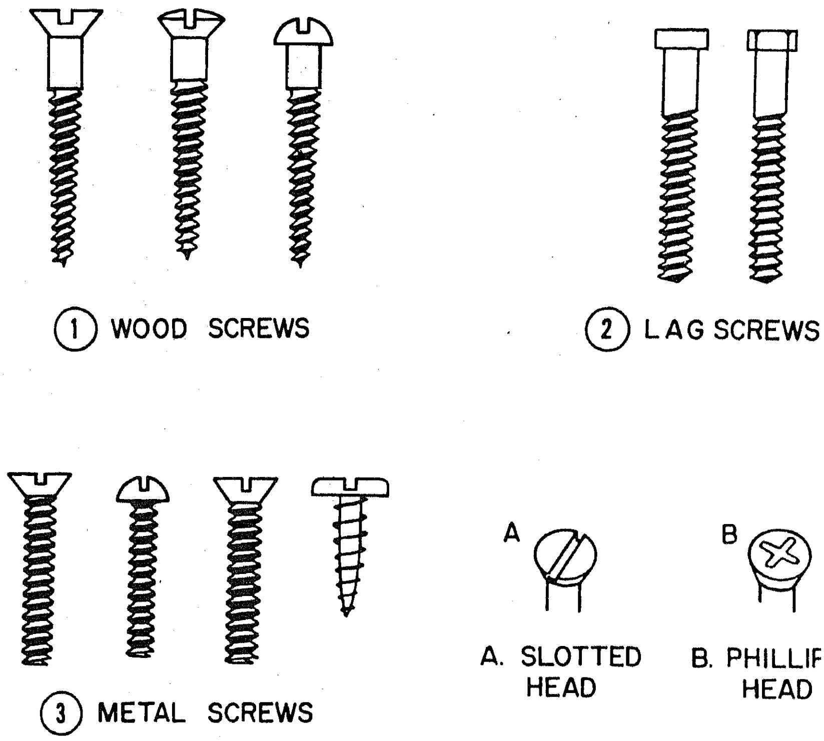


Figure 9. Types of screws.

(4) *Sheet metal screws.* For the assembly of metal p
sheet metal screws are used. These screws are ı
regularly in steel and brass with four types of he:
flat, round, oval, and fillister, as shown in that orde
3, figure 9.

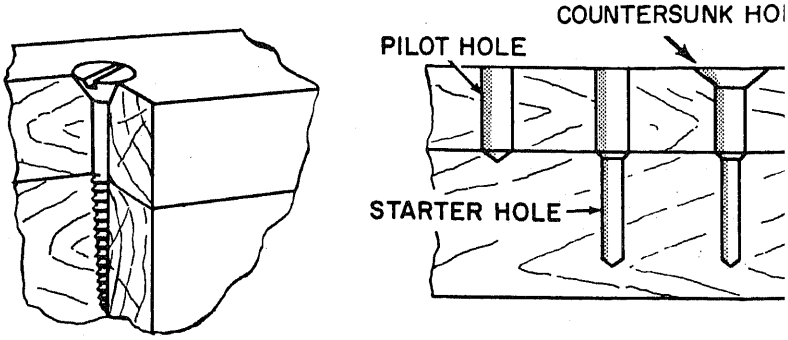


Figure 10. Sinking screw properly.

c. Wood Screw Sizes (fig. 11). Wood screws come in sizes wl vary from ¼ inch to 6 inches. Screws up to 1 inch in length crease by eighths, screws from 1 to 3 inches increase by quart and screws from 3 to 6 inches increase by half-inches. Scre vary in length and size of shaft. Each length is made in a number of shaft sizes specified by an arbitrary number that represents no particular measurement but indicates relative differences in the diameter of the screws. Proper nomenclature of a screw includes the type, material, finish, length, and screw size number which indicates the wire gage of the body, drill or bit size for the body hole, and drill or bit size for the starter hole. Tables VI and VII provide size, length, gage, and applicable drill and auger bit sizes for screws; table VIII gives lengths and diameters of lag screws.

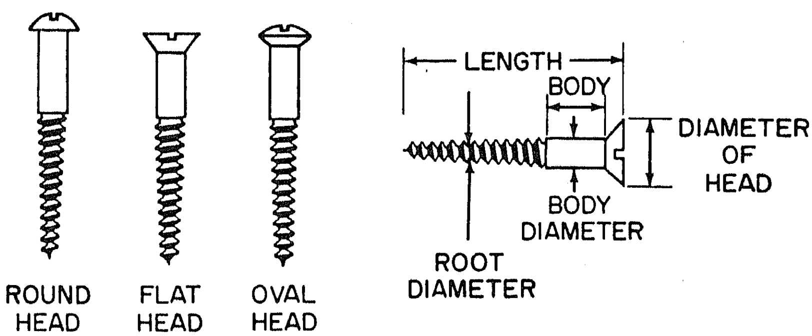


Figure 11. Types of wood screws and nomenclature.

Table VI. S

Length (in.)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	24	26	28	30
¼	x	x	x	x																					
⅜	x	x	x	x	x	x	x	x	x	x															
½		x	x	x	x	x	x	x	x	x	x	x	x												
⅝		x	x	x	x	x	x	x	x	x	x	x	x	x	x										
¾			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								
⅞			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								
1				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					
1¼					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
1½					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
1¾						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2¼						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2½						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
2¾							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
3							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
3½									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
4									x	x	x	x	x		x		x	x	x	x	x	x	x	x	
4½													x		x		x		x	x	x	x	x	x	x
5													x		x		x		x	x	x	x	x	x	x
6															x		x		x	x	x	x	x	x	x

Gage and diameter													
Steel wire gage	17	15	14	13	12	11	10	9	8	7	6½	6	5
Diameter (inches)	.054	.072	.080	.091	.105	.120	.135	.148	.162	.177	.184	.192	.207
Steel wire gage	4½	4	3	2½	2	1	½	0	00	00½	000	0000	
Diameter (inches)	.216	.225	.243	.253	.262	.283	—	.306	.331	—	.362	.393	

Table VII. Drill and Auger Bit Sizes for Wood Screws

Screw size No.		1	2	3	4	5	6	7	8	9	10	12	14	16	18
Nominal screw		.073	.086	.099	.112	.125	.138	.151	.164	.177	.190	.216	.242	.268	.294
Body diameter		$\frac{5}{64}$	$\frac{3}{32}$	$\frac{3}{32}$	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{9}{64}$	$\frac{5}{32}$	$\frac{11}{64}$	$\frac{11}{64}$	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{15}{64}$	$\frac{17}{64}$	$\frac{19}{64}$
Pilot hole	Drill size	$\frac{5}{64}$	$\frac{3}{32}$	$\frac{7}{64}$	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{9}{64}$	$\frac{5}{32}$	$\frac{11}{64}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{7}{32}$	$\frac{1}{4}$	$\frac{17}{64}$	$\frac{19}{64}$
	Bit size	------	------	------	------	------	------	------	------	------	------	4	4	5	5
Starter hole	Drill size	------	$\frac{1}{16}$	$\frac{1}{16}$	$\frac{5}{64}$	$\frac{5}{64}$	$\frac{3}{32}$	$\frac{7}{64}$	$\frac{7}{64}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{9}{64}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{13}{64}$
	Bit size	------	------	------	------	------	------	------	------	------	------	------	------	------	4

Table VIII. Lag Screws

Lengths (inches)	¼	Diameters (inches)		
		⅜, 7/16, ½	⅝, ¾	⅞, 1
1	x	x		
1½	x	x	x	
2, 2½, 3, 3½, etc., 7½, 8 to 10	x	x	x	x
11 to 12		x	x	x
13 to 16			x	x

18. Bolts

a. General. Bolts are used in construction when great strength is required or when the work under construction must be frequently disassembled. Their use usually implies the use of nuts for fastening and sometimes the use of washers to protect the surface of the material they are used to fasten. Bolts are selected for application to specific requirements in terms of length, diameter, threads, style of head, and type. Proper selection of head style and type of bolt will result in good appearance as well as good construction. The use of washers between the nut and a wood surface or between both the nut and the head and their opposing surfaces will avoid marring the surfaces and permit additional torque in tightening.

b. Carriage Bolts. Carriage bolts fall into three categories: bolt, square neck (1, fig. 12); bolt, finned neck (2, fig. 12); and bolt, ribbed neck (3, fig. 12). These bolts have roundheads that are not designed to be driven. They are threaded only part of the way up the shaft; usually the threads are two to four times the diameter of the bolt in length. In each type of carriage bolt, the upper part of the shank, immediately below the head, is designed to grip the material in which the bolt is inserted and keep the bolt from turning when a nut is tightened down on it or removed. The finned type is designed with two or more fins extending from the head to the shank. The ribbed type is designed with longitudinal ribs, splines, or serrations on all or part of a shoulder located immediately beneath the head. Holes bored to receive carriage bolts are bored to be a tight fit for the body of the bolt and counterbored to permit the head of the bolt to fit flush with, or below the surface of, the material being fastened. The bolt is then driven through the hole with a hammer. Carriage bolts are chiefly for wood-to-wood application but may also be used for wood-to-metal applications. If used for wood-to-metal

application, the head should be fitted to the wood item. Metal surfaces are sometimes predrilled and countersunk to permit the use of carriage bolts metal-to-metal. Carriage bolts can be obtained from ¼ inch to 1 inch in diameter, and from ¾ inch to 20 inches long (table IX). A common flat washer should be used with carriage bolts between the nut and the wood surface.

Table IX. Carriage Bolts

Lengths (inches)	Diameters (inches)			
	3/16, ¼, 5/16, ⅜	7/16, ½	9/16, ⅝	¾
¾	x	----------	----------	----------
1	x	x	----------	----------
1¼	x	x	x	----------
1½, 2, 2½, etc., 9½, 10 to 20	x	x	x	x

c. Screw, Cap (Machine Bolts). Machine bolts (4, fig. 12) are made with cut National Fine or National Coarse threads extending in length from twice the diameter of the bolt plus ¼ inch (for bolts less than 6 inches in length), to twice the diameter of the bolt plus ½ inch (for bolts over 6 inches in length). They are precision made and generally applied metal-to-metal where close tolerance is desirable. The head may be square, hexagon, double hexagon, rounded, or flat countersunk. The nut usually corresponds in shape to the head of the bolt with which it is used. Machine bolts are externally driven only. Selection of the proper machine bolt is made on the basis of head style, length, diameter, number of threads per inch, and coarseness of thread. The hole through which the bolt is to pass is bored to the same diameter as the bolt. Machine bolts are made in diameters from ¼ inch to 3 inches and may be obtained in any length desired (table X).

Table X. Screw, Cap (Machine Bolts)

Lengths (inches)	Diameters (inches)				
	¼, ⅜	7/16	½, 9/16, ⅝	¾, ⅞, 1	1⅛, 1¼
¾	x	----------	----------	----------	----------
1, 1¼	x	x	x	----------	----------
1½, 2, 2½	x	x	x	x	----------
3, 3½, 4, 4½, etc., 9½, 10 to 20.	x	x	x	x	x
21 to 25	----------	----------	x	x	x
26 to 39	----------	----------	----------	x	x

'. *Stove Bolts.* Stove bolts (5, fig. 12) are less precisely made n machine bolts. They are made with either flat or round ted heads and may have threads extending over the full length ʰᵉ body, over part of the body, or over most of the body. They ıerally used with square nuts and applied metal-to-metal, ›-wood, or wood-to-metal. If flatheaded, they are counter- ᶠ roundheaded, they are drawn flush to the surface.

pansion Bolts. An expansion bolt (6, fig. 12) is a bolt onjunction with an expansion shield to provide anchorage ınces in which a threaded fastener alone is useless. The

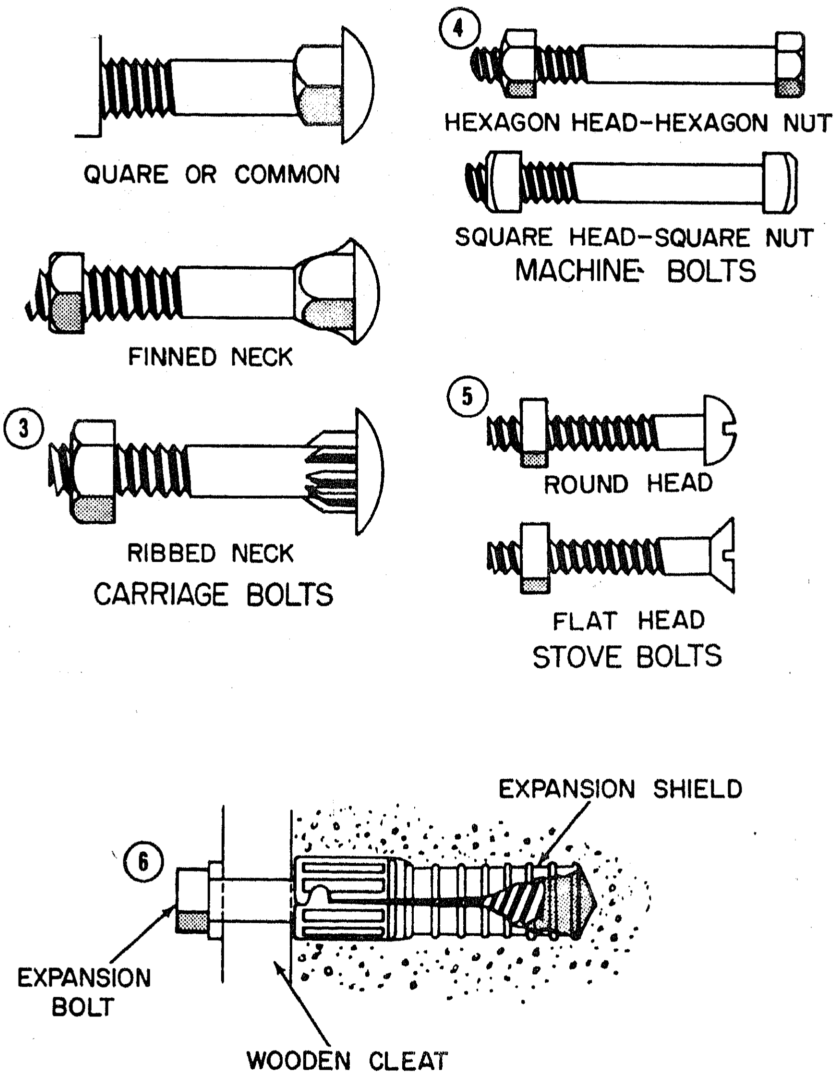


Figure 12. Types of bolts.

shield, or expansion anchor, inserted in a predrilled hole expands when the bolt is driven into it and becomes wedged firmly in the hole, providing a secure base for the grip of the fastener.

19. Driftpins

a. General. Driftpins are long, heavy, threadless bolts used to hold heavy pieces of timber together (fig. 13). The term "driftpin" is almost universally used in practice. However, for supply purposes the correct designation is "driftbolt".

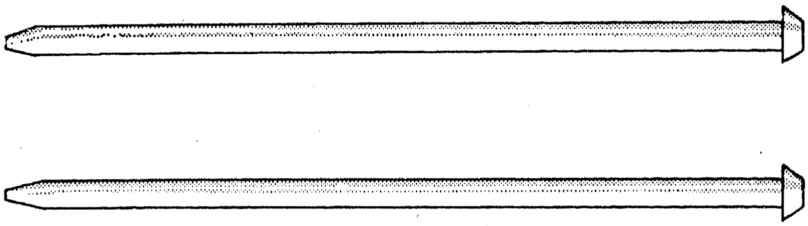


Figure 13. Driftpins (driftbolts).

b. Types. Driftpins have heads and they vary in diameter from ½ to 1 inch, and in length from 18 to 26 inches.

c. Uses. To use the driftpin, a hole slightly smaller than the diameter of the pin is made in the timber. The pin is driven into the hole and is held in place by the compression action of the wood fibers.

20. Corrugated Fasteners

a. General. The corrugated fastener is one of the many means by which joints and splices are fastened in small timber and boards. It is used particularly in the miter joint. Corrugated fasteners are made of sheet metal of 18 to 22 gage with alternate ridges and grooves; the ridges vary from 3/16 to 5/16 inch, center to center. One end is cut square; the other end is sharpened with beveled edges.

b. Types. There are two types of corrugated fasteners: One with the ridges running parallel (1, fig. 14); the other with ridges running at a slight angle to one another (2, fig. 14). The latter type has a tendency to compress the material since the ridges and grooves are closer at the top than at the bottom.

c. Size. These fasteners are made in several different lengths and widths. The width varies from ⅝ to 1⅛ inches, while the length varies from ¼ to ¾ inch. The fasteners also are made with different numbers of ridges, ranging from three to six ridges per fastener.

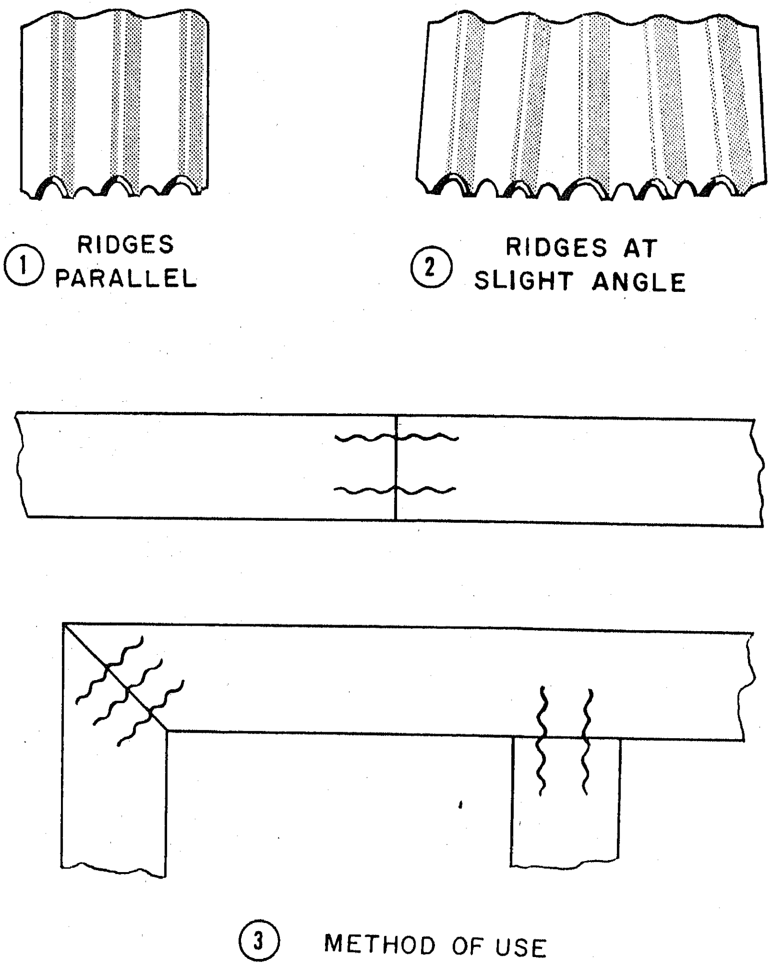


Figure 14. Corrugated fasteners and their uses.

d. Use. Corrugated fasteners are used in a number of ways; to fasten parallel boards together, as in fastening tabletops; to make any type of joint; and as a substitute for nails where nails may split the timber. The fasteners have a greater holding power than nails in small timber. The proper method of using the fasteners is shown in 3, figure 14.

21. Timber Connectors

a. General. Timber connectors are metal devices for increasing the joint strength in timber structures. Efficient connections for either timber-to-timber joints or timber-to-steel joints are provided by the several types of timber connectors. The appropriate type for a specific structure is determined primarily by the kind

of joint to be made and the load to be carried. The connectors eliminate much complicated framing of joints. Some of their important advantages are—they simplify the design of heavy construction; they give greater efficiency of material; they reduce the amount of timber and hardware used; and they save much time and labor.

b. Types and Uses.

(1) Split rings are made of low-carbon steel and are available with 2½- and 4-inch diameters. They are used between two timber faces for heavy construction. They fit into grooves which are cut half the depth of the ring

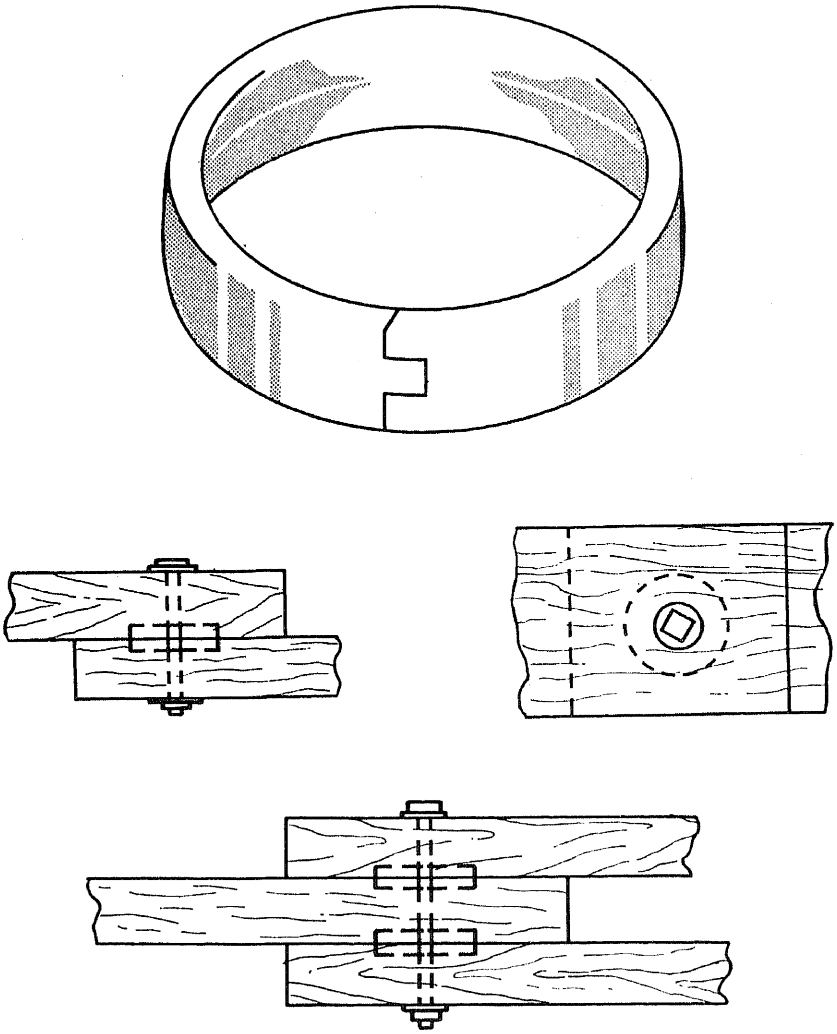


Figure 15. Split ring and its installation.

into each of the timber faces (fig. 15). The grooves are made with a special bit used in an electric, air, or hand drill (fig. 16). The tongue-and-groove split in the ring permits simultaneously ring bearing against the cone wall and outer wall of the groove into which the ring is placed. The inside bevel and mill edge facilitate installation into and removal from the groove.

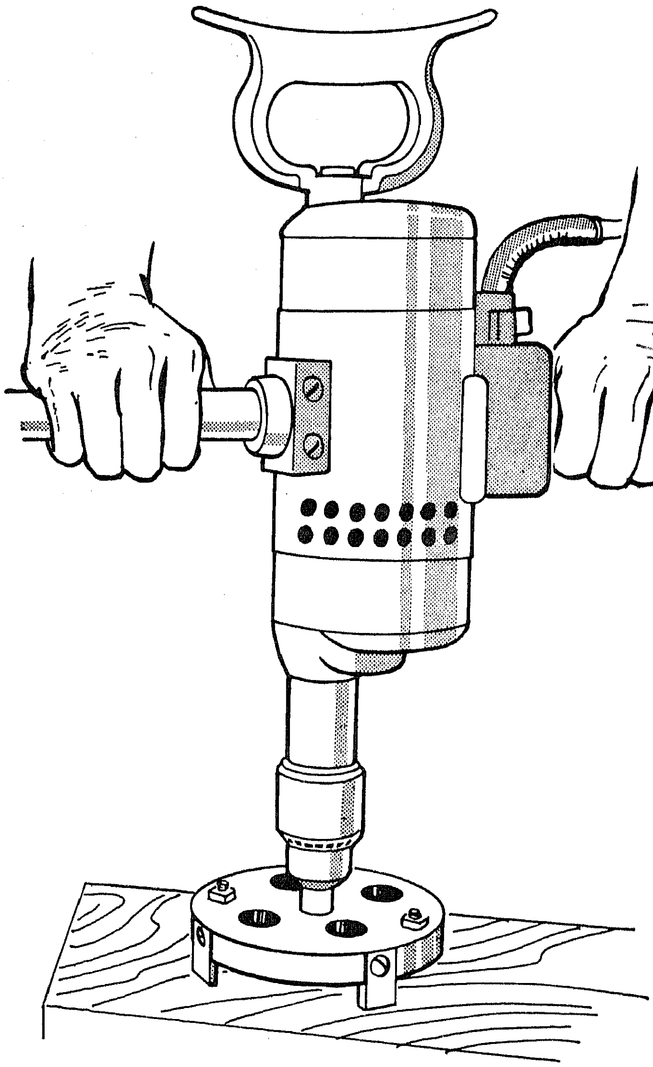


Figure 16. Method of cutting grooves.

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(2) Toothed rings are corrugated and toothed, and ar
from 16-gage plate low-carbon steel (fig. 17)
used between two timber frames for compar
construction and are embedded into the con
the joint members by means of pressure (fig. 18).

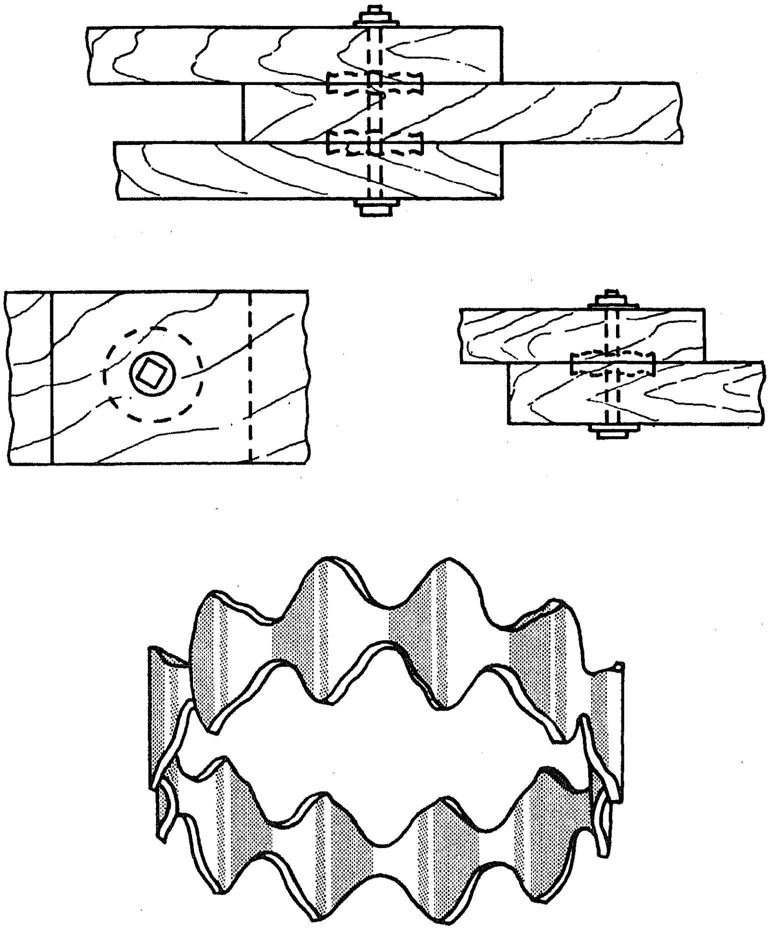


Figure 17. Toothed ring.

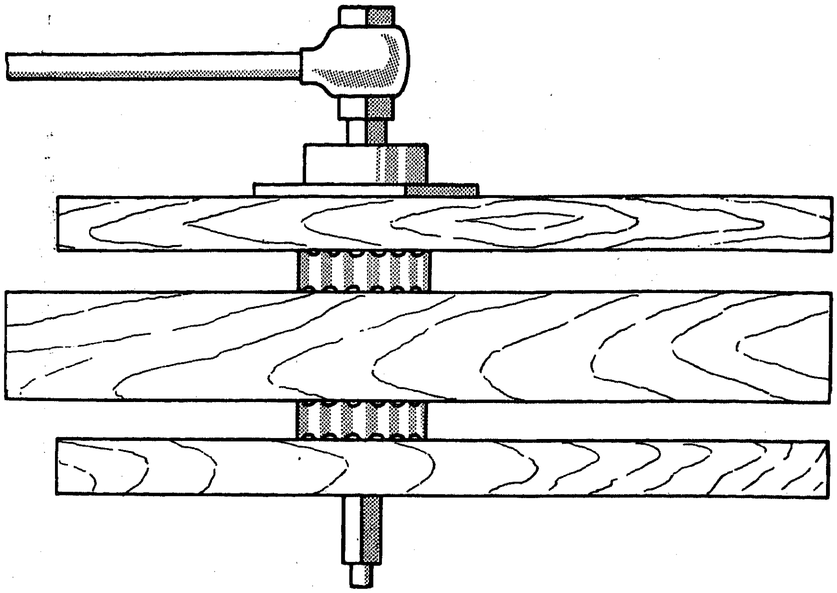


Figure 18. Installation of toothed ring.

CHAPTER 4

LAYOUT AND FOUNDATIONS

22. General

The term "layout" refers to those standard and necessary operations performed in preparing materials and work area prior to the actual commencement of any job. It may be applied to the routine procedures followed in preparing a piece of wood for cutting or to the initial preparation of the exact building site prior to its excavation and the erection of a building. Laying out a job properly, before beginning the actual construction or fabrication, is essential to beginning the work properly. It is also essential to completing it properly. The following instructions apply to laying out an area on which building construction is to take place. As soon as the site of construction has been designated, layout may be begun.

23. Tools and Materials

a. General. The tools and materials used in layout work must be carefully selected to assure accuracy. The materials should be straight and sound and the tools in good condition. Preservation and care of hand tools under varying conditions are covered in TM 5–461. The tools and materials most commonly used in laying out buildings are shown below.

b. Sledge Hammer or Maul. A sledge hammer or maul is needed to sink corner stakes or batter board posts.

c. Post-Hole Auger. A post-hole auger may be required to set posts properly in some soils.

d. Hand Saw. A hand saw is needed to cut batter boards and posts to desired lengths.

e. Chalkline (1, fig. 19). A chalkline is used to make a straight line between two points too far apart to permit the efficient use of a straightedge. It is a white braided or twisted cotton mason's line, usually about 50 feet in length and consisting of a reel, line, and chalk. The chalkline is coated with chalk and stretched taut between two points to be connected by a straight line, just off the surface on which the points are located. The line is then snapped so that its vibration brings it sharply into contact with the sur-

face over or beside which (in the case of vertical surfaces) it is suspended. The chalkline resulting from the forceful contact of the chalky cord with the surface is a quickly achieved, approximately straight guideline. It may be utilized to mark off lines on the ground and on floors, walls, and roofs.

f. Tracing Tape (2, fig. 19). Tracing tape, or layout line (as it is sometimes called), is a cotton tape approximately 1 inch wide. It is most commonly used in lengths of approximately 200 feet, wound on a stick much as fishing line is wound. It is used for laying out excavation or foundation lines of considerable length.

g. Ax or Hatchet. An ax or hatchet is used during the staking out operation to sharpen the ends of batter board posts and corner stakes.

h. Hammer. A hammer is needed for erecting batter boards.

i. Posts or Stakes. Batter board posts are made to the desired lengths from 2 by 4's or 4 by 4's. Corner stakes are made from 4 by 4's, and batter boards from 1 by 4's or 1 by 6's.

j. Carpenter's Level (3 and 4, fig. 19). The carpenter's level is used for determining the levelness of surfaces and for sighting level lines (fig. 27). It may be applied directly to the surface to be checked or used in conjunction with a straightedge (4, fig. 19). The degree of levelness is indicated by the position of spirit bubbles suspended in spirit within transparent glass tubes mounted parallel to one or more surfaces of the level.

k. Straightedge (4 and 5, fig. 19). The straightedge is usually constructed with a handhole for easy portability (5, fig. 19), a long bottom edge at least 30 inches in length that is used as the leveling surface, and a shorter, top edge, 8 to 10 inches in length, used as a working surface. The working surface is parallel to the leveling surface, may be lined as a guide, and may be used in conjunction with a level (4, fig. 19), to increase the leveling surface and increase the area checked. The straightedge is most often used to lay out straight lines between points sufficiently close enough to permit the use of the straightedge as a ruler.

l. Line Level (6, fig. 19). The line level utilizes a spirit bubble to indicate levelness and is so constructed as to permit it to be suspended from the line to be leveled. Placing the line level at the midpoint on the line between the two points being leveled insures the greatest accuracy.

m. Engineer's Transit or Leveling Instrument. The engineer's transit or leveling instrument is used to establish a proper reference or grade line from which the builder may build up or down with consistent accuracy as to vertical level. This is done to

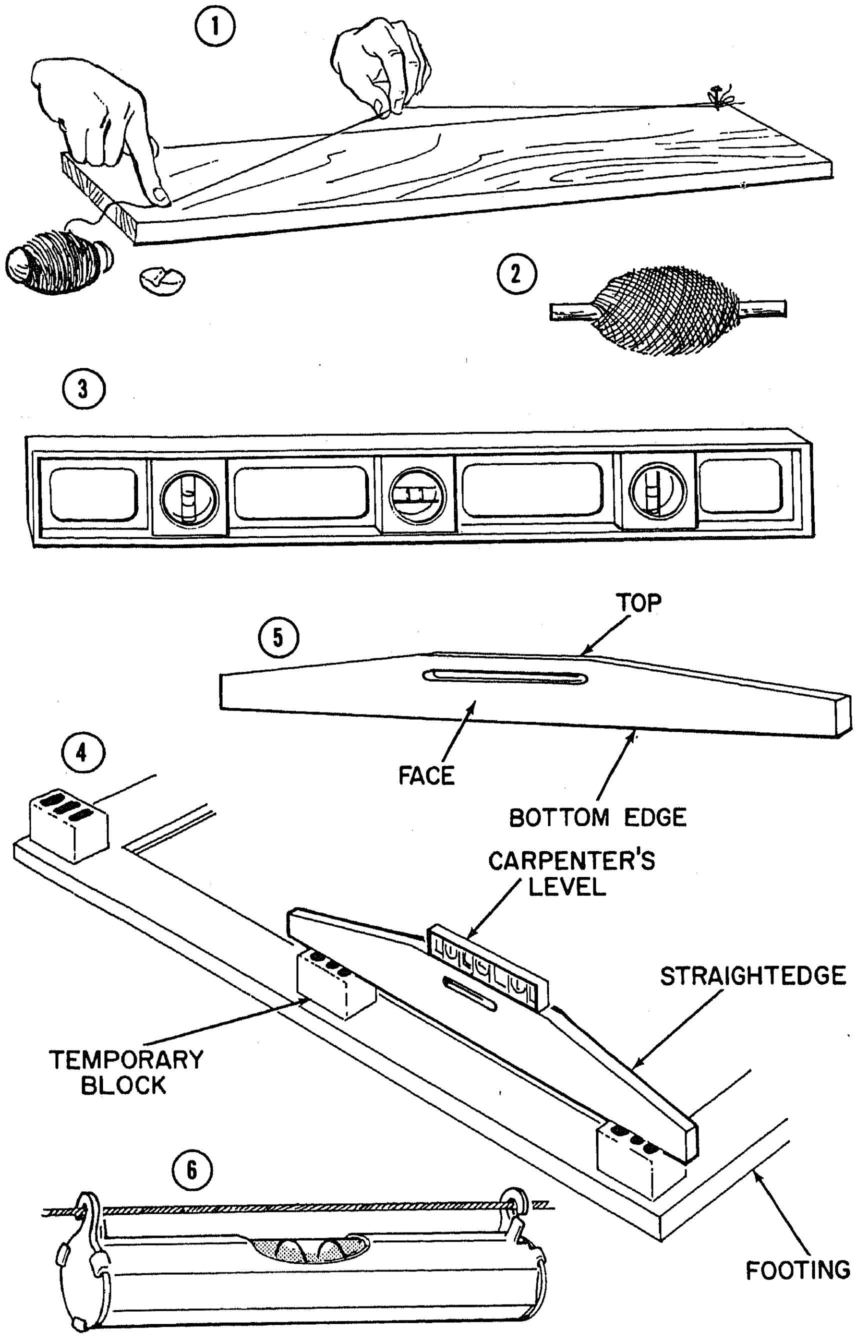


Figure 19. Layout tools.

establish location points for the corners of buildings or excavations, and to lay out lines along which construction or excavation will take place.

(1) *Engineer's transit or level* (fig. 20). The engineer's transit or level consists of an adjustable tripod and head. It is used in conjunction with a leveling rod. The head is mounted to the tripod by a ball and socket joint and is so constructed that it may be adjusted horizontally and vertically. The sight tube of the head is mounted to a

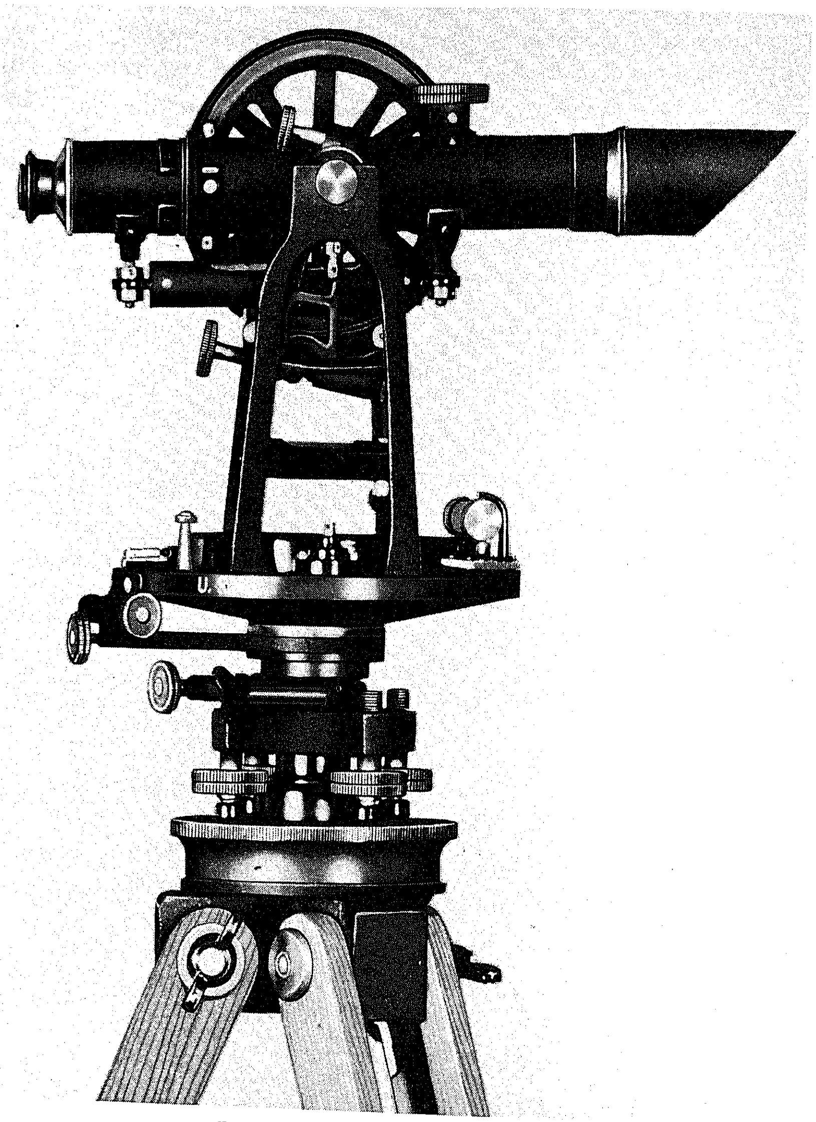
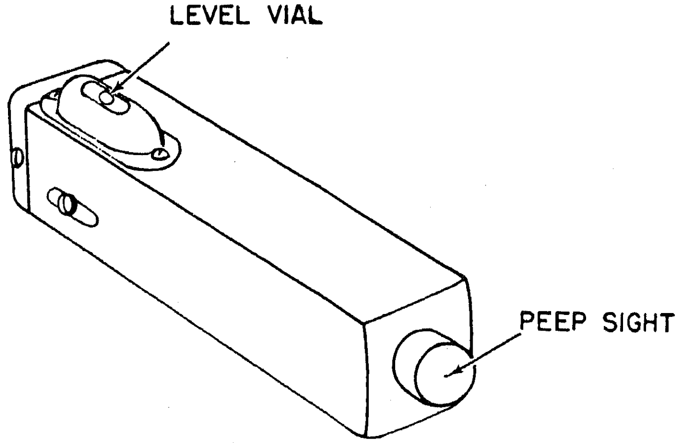


Figure 20. Engineer's transit.

vertical arc that permits vertical adjustment and on which a spirit level is mounted so that the sight tube may be brought to level by adjustment of the head thumbscrews. The head plate, upon which the sight tube and vertical arc are mounted, is graduated in degrees to permit setting the sight tube at various angles on a horizontal plane when shooting horizontal points. For complete instruction on the proper use of the engineer's transit, see TM 5–232.

(2) *Locator's Hand Level* (fig. 21). The locator's hand level is used to measure approximate differences in elevation and may be used to establish grades over limited distances. This instrument consists of a metal sighting tube



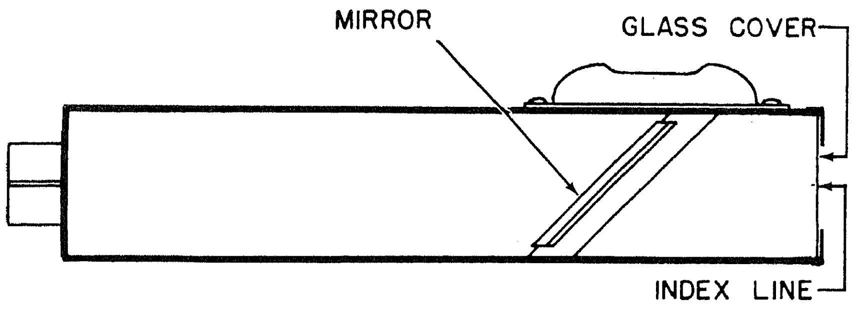


Figure 21. Leveling instrument.

with plain glass covers at the ends and a level vial mounted on the tube. It is usually hand held in front at the eye. The landscape, level bubble, and index line are seen in the tube.

24. Use of the Engineer's Transit

(fig. 22)

a. Set up the engineer's transit so that it is centered directly over the station mark (A). The station mark is the point from which layout is to be sighted or shot and may be a bench mark or a corner of the lot (or a point on the periphery of the area) on which construction is to take place. In builtup areas, a bench mark (B) may have been provided by surveying engineers to be used as a point of reference. The bench mark may appear as a mark, or point, on the foundation of an adjacent building, a stone marker buried at a designated location, or may be taken from sidewalk or street levels. Street curbing is used extensively to provide a bench mark since the purpose of the bench mark is to provide a reference for establishing a grade line which will usually be a given height above curb level. If bench marks have been established in the area on which construction is to take place and the architect's drawings to be used have been created specifically for that particular area, the bench mark will appear on the drawings and the plans will be oriented to that point. If no bench mark exists, a post may be driven into the ground at an appropriate spot to provide this reference point. This post can be used to establish floor levels, foundation levels, or any definite point of elevation. When setting up the engineer's transit or leveling instrument, a plumb bob, suspended from the hook provided under the head of the instrument, may be used to center the instrument directly over the selected station mark.

b. Set up the engineer's transit where both the surveyors bench (B) mark and the area of the plot may be conveniently sighted. Adjust the tripod of the transit so that it rests firmly on the ground, with the sighting tube at eye level. Level up the head of the instrument by turning the leveling screws, so that the sight tube and head will be level when turned in any direction. Once the transit is properly set up, all physical contact with the legs of the tripod should be avoided.

c. Place a leveling rod (C) upright on any point to be checked, and sight through the sight tube of the instrument at the leveling rod. In accurate work, a spirit level may be attached to the leveling rod to check if the rod is being held plumb. An assistant should hold the leveling rod, and should move the target on the rod up or

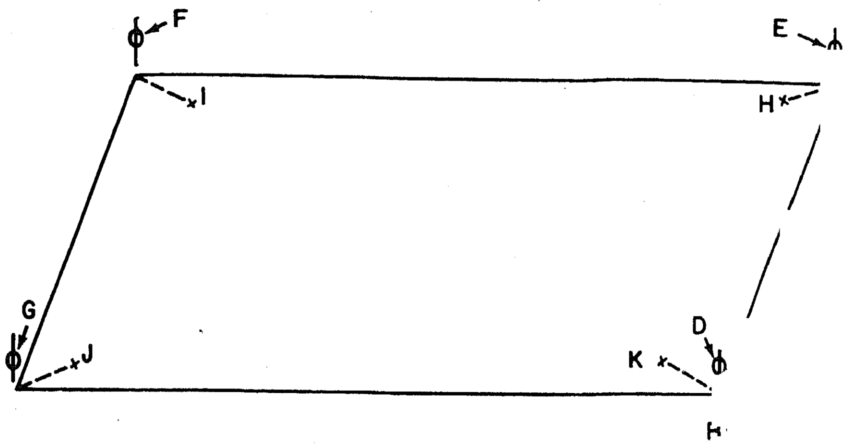


Figure 22. Layout of a plot with an engineer's transit.

down until the crossline on the target comes in line with the cross-hair sights in the sighting tube.

d. To obtain the difference in elevation between two points, such as the surveyor's bench mark (B) and the target point (D), hold the rod on the point (B) and take a rod reading. This will be the length of the bottom of the rod below the line of sight. Take a rod reading at point (D). The difference between the two rod readings is the difference between the elevations of the two points.

Note. When the target height has been established on each corner or point to be tested, these heights will be in the same horizontal plane as the cross-hairs of the instrument.

e. To establish a level for the depth of an excavation or for the level of foundation walls, measure equal distances at all corners from these target points to the desired elevations (H, I, J, and K).

f. To lay out a right angle with an engineer's transit, set up the transit directly over the line (use plumb bob) at the point where the right angle is to occur (A, fig. 23). Sight a reference point on that line (B) to be sure the transverse axis of the engineer's transit is parallel to the line. Turn the eyepiece end of the sight tube to the left until the scale indicates that an arc of 90° has been completed. Establish a leveling rod in position along this line of sight at the desired distance. A line extended from the leveling rod (D) to the point from which the sight was taken will be perpendicular to the base line and will form a right angle at the point at which they bisect (DAB).

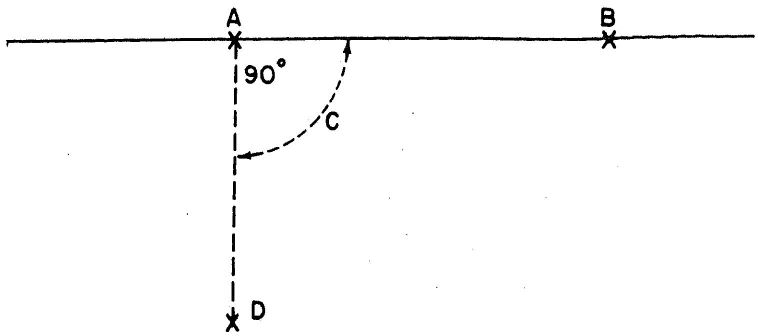


Figure 23. Laying out a right angle with an engineer's transit.

25. Staking Out

When the location and alinement of a building have been determined, a rectangle comprising the exterior dimensions of the structure is staked out. If the building is to be of simple rectangular structure, a rectangle comprising the exact exterior of the planned space or foundation line is staked out (pars. 26 and 27). If the outline of the building is to be other than rectangular, a rectangle large enough to comprise the major outline of the irregular structure is staked out and the irregularities plotted and proved by smaller rectangles within or without the basic form (par. 28).

26. Laying Out a Simple Rectangle Without Use of an Engineer's Transit or Leveling Instrument

If excavation or construction is to be carried out parallel to an identifiable line that may be used as a guide and point of reference, such as a street or property line, staking out may be accomplished without the use of a builder's transit. If a street or clearly defined line to which the excavation or construction is to run parallel is present (AB) and the property lines or maximum outer perimeter of the building area (AC, CD, DB) are known, proceed in the following manner:

a. Measure away from the front line (AB) along the side lines (AC and BD) the distances (AO and BO) desired to the dimension of the project that is to run parallel to the front line.

b. Stretch a line tightly from point O to O. This line will mark out what will be frontage of the project.

c. Measure in from lines AC and BD along line OO, one-half the difference between the length of OO and the desired length of the project. The points (X and X, fig. 24) obtained by so doing will constitute the front corners of the project.

d. The two distances, OX and XO, establish the distance E and F. Extending lines from the two front corners, X and X, parallel

to AC and BD at the distances established as E and F for the required depth of the project provides the side lines of the project XG and XH.

e. Joining the extreme ends of side lines XG and XH will provide the rear line of the project.

f. After the four corners (X, X, G, and H) have been located, drive stakes at each corner. Batter boards may be erected at these points either after all the stakes have been set or while they are being set (par. 30). Dimensions are determined accurately during each step.

g. If the building is not rectangular, several lines such as OO may be run and appropriate adjacent rectangles constructed from these lines in the same fashion as indicated above.

27. Laying Out a Simple Rectangle With an Engineer's Transit or Leveling Instrument

(1, fig. 25)

a. Working from an established line AB such as a road or street line, property line, or an established reference line, select a point to represent the lateral limit for a front corner of the project.

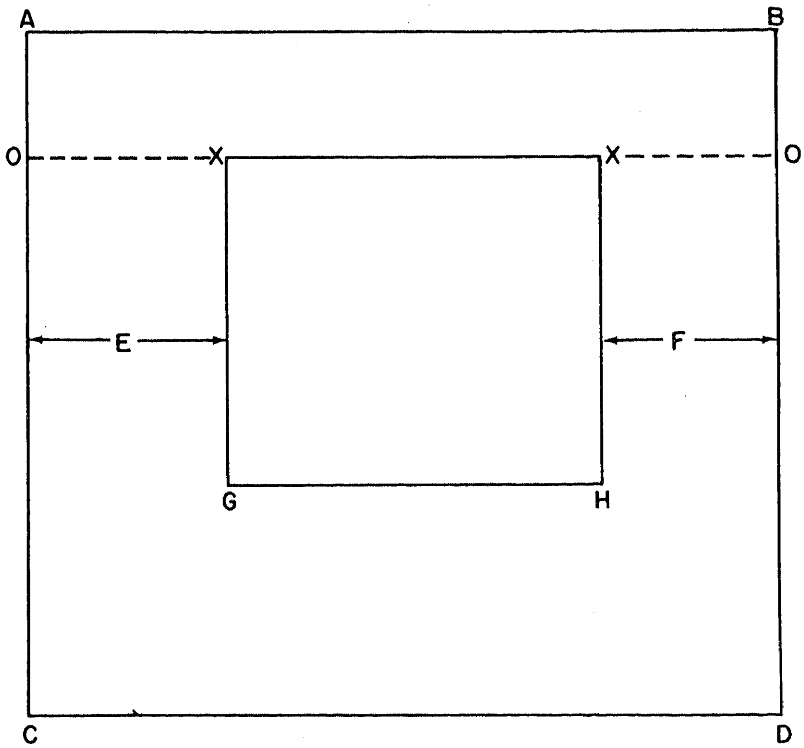


Figure 24. Staking out rectangle without use of transit.

b. Set up the engineer's transit (par. 24) at point C and establish point D, a front corner of the project.

c. Set up the engineer's transit at a point E a greater distance along line AB from point C than the intended length of the project. Set a stake at F, the same distance from AB as D. CD and EF are equal.

d. Establish the front line of the project by marking off the length of the project DG along the established line DF. The two front corners of the project will be located at D and G.

e. With engineer's transit set up at point C, shoot E and then swing the transit 90° (par. 24*f*) and sight along this position to establish H, the rear corner of the project.

f. With the engineer's transit set up at G, sight D and swing the transit sight tube 90° and shoot I, the other rear corner of the project.

g. To prove the work, set up the transit at I and take a sighting on H. If IH is equal to DG, the work is correct. If it is not, the work must be repeated until correct.

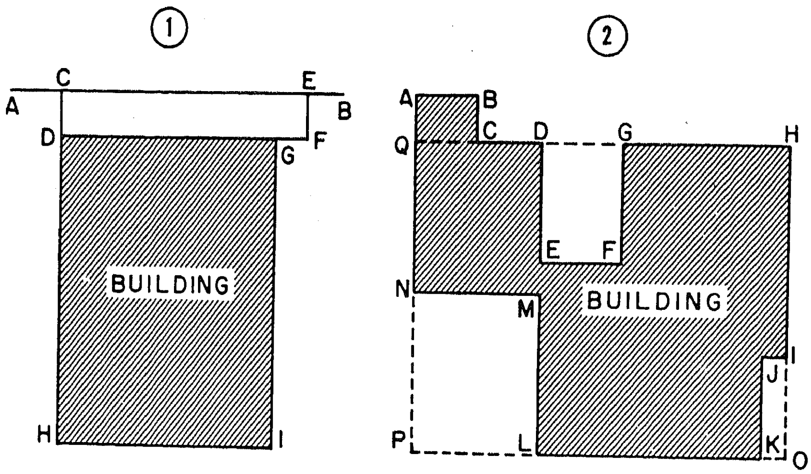


Figure 25. Laying out regular and irregular projects.

28. Laying Out an Irregularly Shaped Project (2, fig. 25)

Where the outline of the building is other than a rectangle, the procedure in establishing each point is the same as described above, but more points have to be located and the final proving of the work is more likely to reveal a small error. It is usually advisable with an irregularly shaped building to lay out first a large rectangle which will comprise the entire building or a greater part of it. This

is shown in 2, figure 25, as the rectangle HOPQ. Having once established this accurately, the remaining portion of the layout will consist of small rectangles, each of which can be laid out and proved separately. The other rectangles as LMNP, ABCQ, DEFG, and IJKO are illustrated in 2, figure 25.

29. Batter Boards

a. Staking Procedure. At the points at which the various corners of the project are located, a corner stake is driven to mark the exact spot (fig. 26). If the area must be excavated for a foundation, the excavating will disturb the pegs. Batter boards are therefore set up to preserve definite and accurate building lines to work toward or from. This is accomplished by stretching heavy cord or fine wire from one batter board to the other to define the lines of excavations.

b. Locating Batter Boards. Right-angle batter boards are erected 3 or 4 feet outside each corner stake (fig. 26). Straight batter boards are erected 3 or 4 feet outside of the line stakes set at points provided for the extension of foundation lines (fig. 26) which intercept side lines.

c. Construction of Batter Boards. Batter board stakes may be 2 x 4's, 2 x 6's, or 4 x 4's. They must be heavy enough and long enough to be sturdy when driven and withstand all ordinary working conditions. The boards to be attached to the stakes are usually 1 x 6's. Right-angle batter boards usually consist of two 1 x 6 boards and three stakes. The boards can be nailed or bolted to the stakes either before or after they are sunk. Batter boards are firmly anchored and if more than 3 feet high, they are braced. Since the boards should be at the exact height and level of the top of the foundations if possible, it may be desirable to adjust the height by nailing the boards to the stakes after the stakes have be sunk. Right-angle batter boards may be nailed at close to perpendicular by the use of a framing square and should be leveled by means of a carpenter's level before they are secured. When the final adjustments have been made for accuracy and squareness, saw cuts may be made or nails driven into the tops of the boards to hold the lines and keep them in place. Separate cuts or nails may be used for the building line, the foundation line, footing line, and excavation lines. These grooves permit the removal and replacement of the lines in correct position.

30. Extending Lines
(fig. 27)

The following procedure applies to a simple layout and must be amended to apply to different or more complex layout problems:

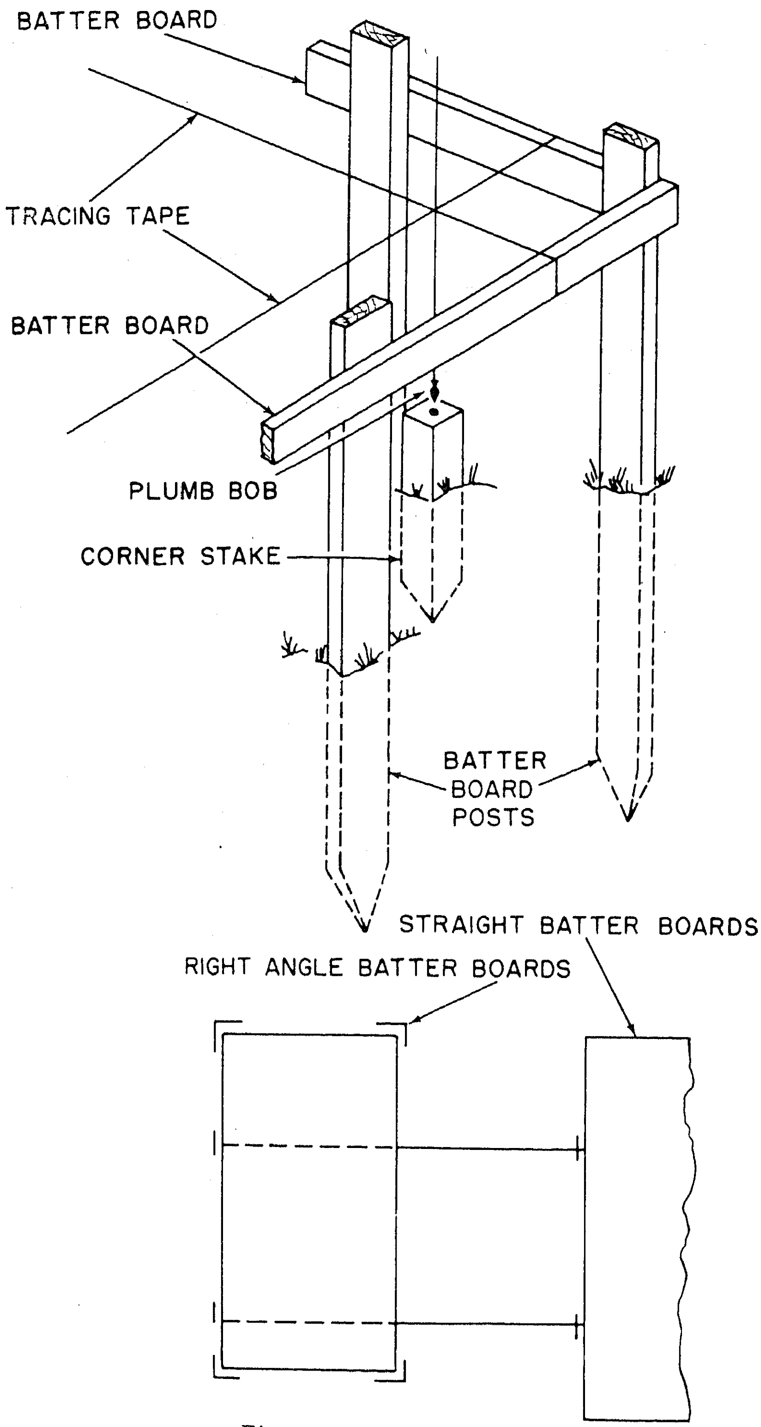


Figure 26. Batter boards.

a. After locating and sinking stakes A and B, erect batter boards 1, 2, 3, and 4. Extend the chalkline X from batter board 1 over stakes A and B to batter board 3.

b. After locating and sinking stake C, erect batter boards 5 and 6. Extend the chalkline Y from batter board 2 over stakes A and C to batter board 6.

c. After locating and sinking stake D, erect batter boards 7 and 8. Extend chalkline Z from batter board 5 over stakes C and D to batter board 7.

d. Extend line O from batter board 8 over stakes D and B to batter board 4.

e. Where foundation walls are wide at the bottom and exten beyond the outside dimensions of the building, the excavation n be larger than the size laid out. To lay out dimensions for excavation, measure out as far as required from the building on each batter board, and stretch lines between these points outside the first layout.

f. The lines may be brought to an approximate right ang where they cross by holding a plumb bob over the corner layou stakes and adjusting the lines until they touch the plumb bob line perfectly.

g. The lines should be checked by means of a line level, or carpenter's level.

31. Squaring Foundation Lines

There are two generally accepted methods for squaring extended lines commonly used by the carpenter: the 6–8–10 method and the diagonal method.

a. *6–8–10 Method* (fig. 27). After lines have been extended and are in place, measure the distance EF (6 feet or a multiple thereof, such as 12 feet). Measure off EG (to a distance of 8 feet if the previous figure used was 6 feet, or to a distance 16 feet if the previous figure was 12 feet). Adjust the lines until FG equal 10 feet if the other two measurements used are 6 feet and 8 feet, or 20 feet if the other two ar 12 feet and 16 feet.

b. *The Diagonal Method* (fig. 27). If the layout is rectangular, line H and I cutting the rectangle from opposing corners will form two triangles. If the rectangle is perfect, these lines will be equal in length and the corners perfectly square. If lines H and I are not equal in length, adjust the corners by moving the lines right or left until H and I are equal.

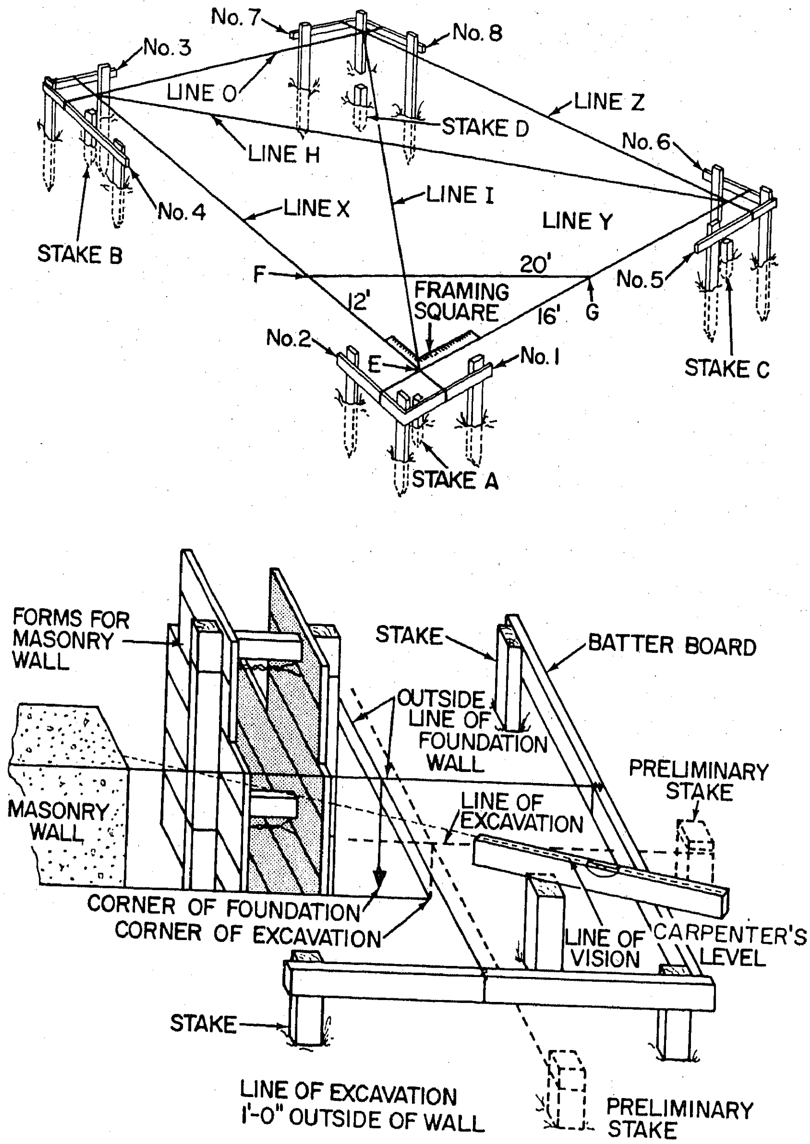


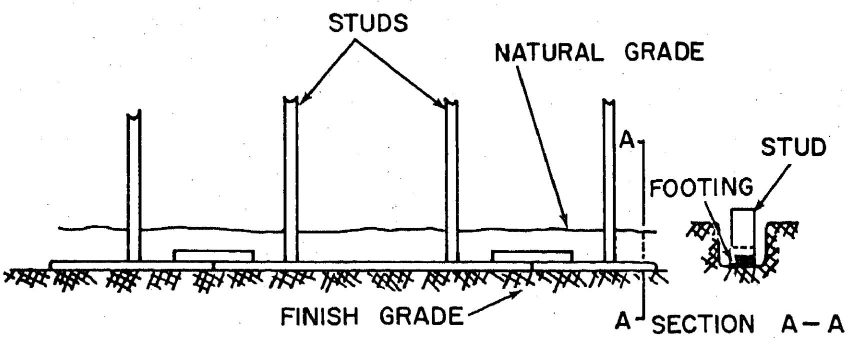
Figure 27. Laying out building lines from batter boards.

32. Foundations

Foundations vary according to their use, the bearing capacity of the soil, and the type of material available. The material may be cut stone, rock, brick, concrete, tile, or wood, depending upon the weight which the foundation is to support. See TM 5–541 for the relation of soil bearing capacity and foundations. Foundations may be classified as wall or column (pier) foundations.

a. Wall Foundations. Wall foundations are built solid, the walls of the building being of continuous heavy construction for their total length. Solid walls are used when there are heavy loads to be carried or where the earth has low supporting strength. These walls may be made of concrete, rock, brick, or cut stone, with a footing at the bottom (fig. 28). For complete information regarding the construction of concrete forms, see TM 5–742. Because of the time, labor, and material required to build it, this type of wall will be used in the theater of operations only when othe types cannot be used. Steel rod reinforcements should be u in all concrete walls.

(1) *Rubble masonry.* Rubble stone masonry is use both above and below ground and for bridge In military construction, it is used when forr masonry units are not available. Rubble m be laid up with or without mortar; if strengt ity are desired, mortar must be used.



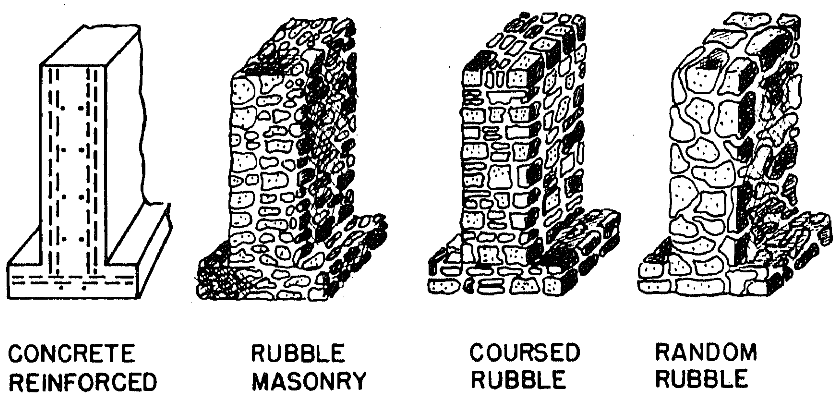


Figure 28. Foundation walls.

(2) *Coursed rubble.* Coursed rubble is assembled of roughly squared stones in such a manner as to produce approximately continuous horizontal bed joints. For complete information regarding the use of rubble materials in masonry, see TM 5–742.

(3) *Random rubble.* This is the crudest of all types of stonework. Little attention is paid to laying the stone in courses. Each layer must contain bonding stones that extend through the wall. This produces a wall that is well tied together.

b. Column or Pier Foundations. Column or pier foundations save time and labor. They may be constructed from masonry or wood.

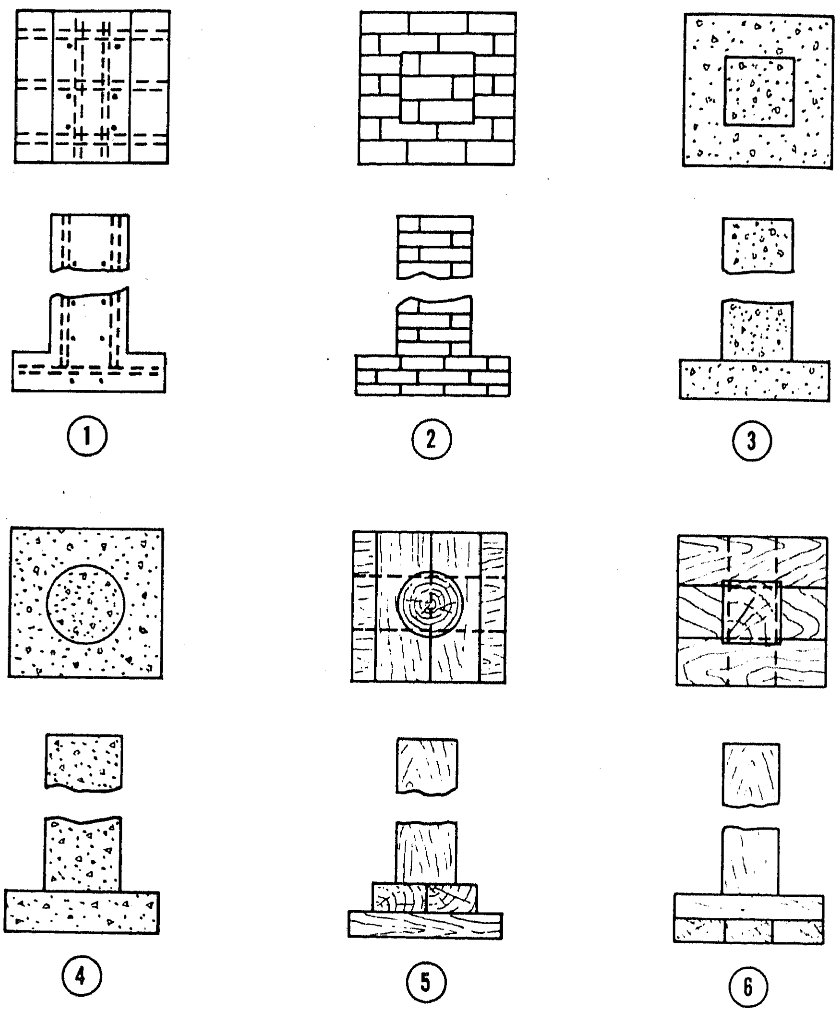


Figure 29. Column and piers.

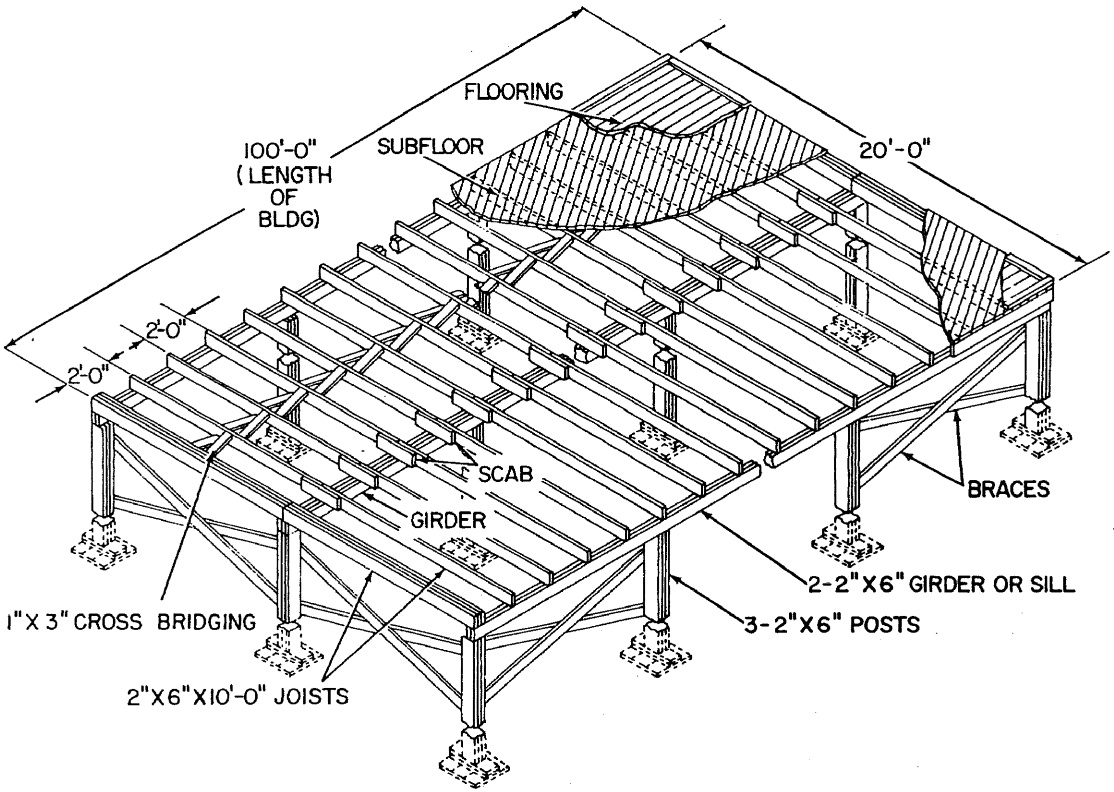


Figure 30. Braced piers, sills, girders

The piers or columns are spaced according to the weight to be carried. In most cases, the spacing is from 6 to 10 feet. Figure 29 showns the different types of piers with different types of footing. Wood piers are generally used since they are installed with the least time and labor. Where wood piers are 3 feet or more above the ground, braces are necessary (fig. 30).

CHAPTER 5
FRAMING

Section I. GENERAL

33. General

After the building has been laid out and the batter boards have been set in place, the carpenter constructs the framing of the building. Framing is a skeleton, or framework, upon which the covering is to be placed. Just as the bony skeleton is the basic supporting structure of the body, so the framework of a building contains its fundamental strength. Framing consists of the foundation walls, exterior walls, flooring, roofing, beams, trusses, partitions, and ceilings.

a. Light-Frame Construction. Much of the framing that must be done, can be done while the staking out and squaring of the building is being completed. As soon as the skeleton, or frame, of a quick construction job is far enough along to be boarded up, boards can be nailed without cutting if the material to be used for roof sheeting and siding is available in even lengths, that is, 8-, 10-, 12-, 14-, 16-, or 18-foot, whichever is stock length. By use of a shifting organization, a large force of men can be kept working systematically without layover for completion of framing. When an advance crew has the skeleton of a building far enough along so the sides can be boarded, additional soldiers may be utilized by nailing on sheathing for the walls and roof. Behind those nailing on boards, a crew can be roofing. But it must be remembered that those men constructing the frame should be the better skilled. For further information regarding light-frame construction and field expedients, see TM 5–302.

b. Substitute, Expedient, and Improvised Framing. The particular form that substitute, expedient, and improvised building may take is usually determined by the existing circumstances, such as the time and place of building, the presence of an emergency, and the form it takes. The ideas included here constitute departures from standard plans and the adaptation of natural materials to some circumstances, and may suggest further expedients that would be adjustable to others. Available material and equipment,

labor, climatic conditions, and local requirements must all be considered before plans are substituted or amended.

(1) *Light siding.* Chicken wire and water resistant bituminous paper can be sandwiched to provide adequate temporary framing in temperate climates.

(2) *Salvaged framing.* Salvaged sheet metal such as corrugated material or gasoline cans can be utilized as framing and siding in the construction of emergency housing.

(3) *Local timber.* Poles trimmed from saplings or bamboo can be constructed into reasonably sound framing. Such materials may be secured with native vines as a further expedient.

(4) *Wood substitute framing.* Adobe soil, straw, and water puddled to proper consistency can be used for form walls, floors, and foundations. A similar mixture may be used to form sun-dried bricks equally adaptable to construction requirements.

(5) *Excavations.* Proper excavation and simple log cribbing may be covered with sod and carefully drained to provide adequate shelter.

34. Wood Framing

a. Light Wood Framing. Light framing is used in barracks, bathhouses, administration buildings, light shop buildings, hospital buildings, and similar structures. When a complete set of drawings is made for a certain building, large scale details are usually shown for typical sections and unusual construction features. Figure 31 shows the various details for overall framing of a 20-foot-wide building showing ground level and including window openings, braces, splices, and nomenclature of framing details.

b. Heavy Framing. Whereas light wood frame buildings are generally constructed to provide maximum economy in terms of time, material, and labor and are generally limited in size and application to housing or storage requirements of a temporary nature, heavy wood frame buildings may be considered as more permanent installations and are usually practical only for such applications as warehousing, depot storage, and shop facilities. Figure 32 shows the various details for heavy framing of a building.

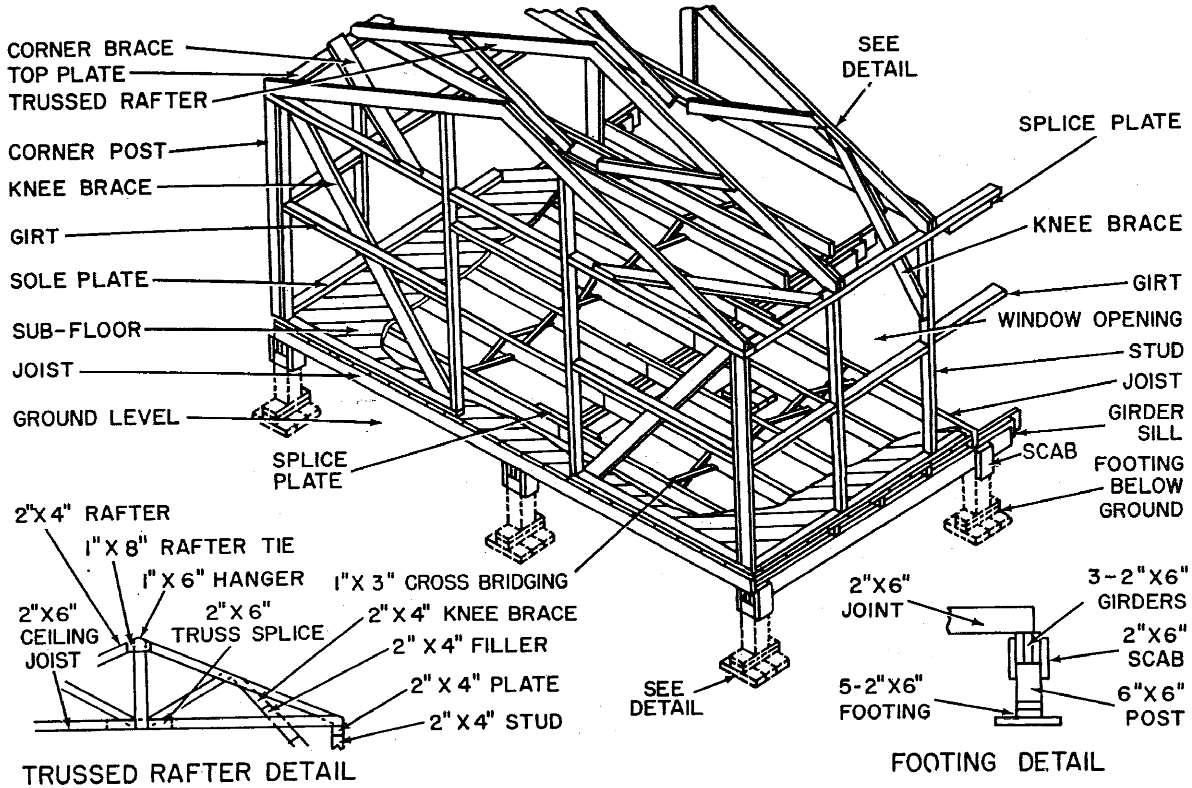


Figure 31. Sectional view of a light frame building.

Section II. SILLS, GIRDERS, AND FLOOR JOISTS

35. Sills

a. The work involved in sill construction is a very important one for the carpenter. The foundation wall is the support upon which all structure rests. The sill is the foundation on which all framing structure rests and it is the real point of departure for actual carpentry and joinery activities. The sills are the first part of the frame to be set in place. They rest either directly on the foundation piers or on the ground, and may extend all around the building; they are joined at the corners and spliced when necessary. Figure 33 shows the most common types of sills. The type used depends upon the general type of construction used in the frame.

(1) *Box sills.* Box sills are used often with the very common style of platform framing, either with or without the sill plate. In this type of sill (1 and 2, fig. 33), the part that lies on the foundation wall or ground is called the sill plate. The sill is laid edgewise on the outside edge of the sill plate.

(2) T-*sills.* There are two types of T-sill construction; one commonly used in the South, or in dry, warm climates (3, fig. 33), and one commonly used in the East or less warm climates (4, fig. 33). Their construction is similar except that in the case of the Eastern T-sill the joists are nailed directly to the studs, as well as to the sills, and headers are used between the floor joists.

(3) *Braced framing sill.* The sill shown in 5, figure 33, is generally used in braced-framing construction. The floor joists are notched out and nailed directly to the sill and studs.

(4) *Built-up sills.* Where built-up sills are used, the joints are staggered (1, fig. 34). The corner joints are made as shown in 2, figure 34.

b. If piers are used in the foundation, heavier sills are used. These sills are of single heavy timbers or are built up of two or more pieces of timber. Where heavy timber or built-up type sills are used, the joints should occur over piers. The size of the sill depends upon the load to be carried and upon the spacing of the piers. The sill plates are laid directly on graded earth or on piers. Where earth floors are used, the studs are nailed directly to the sill plate.

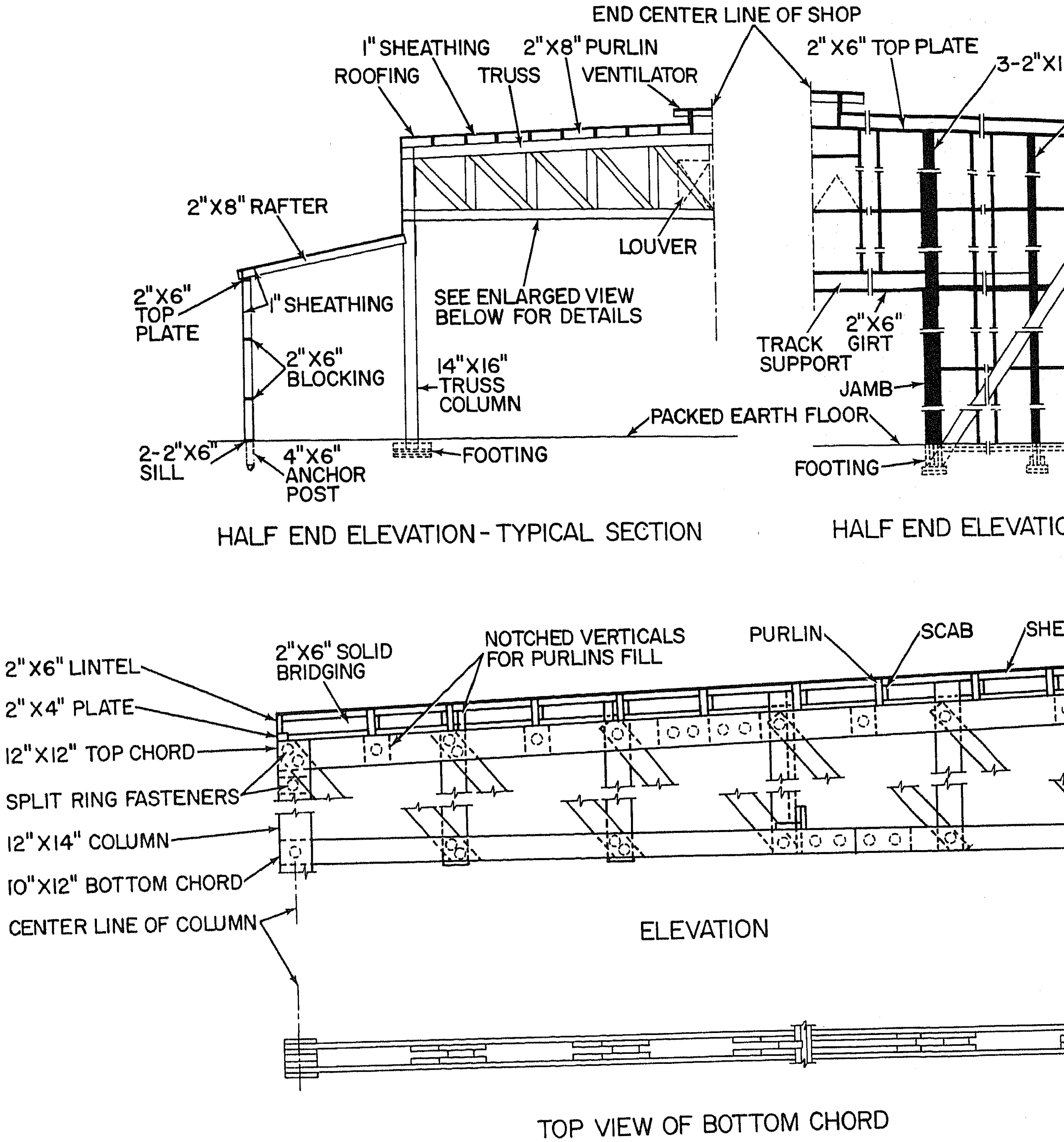


Figure 32. Sectional view of a heavy frame building.

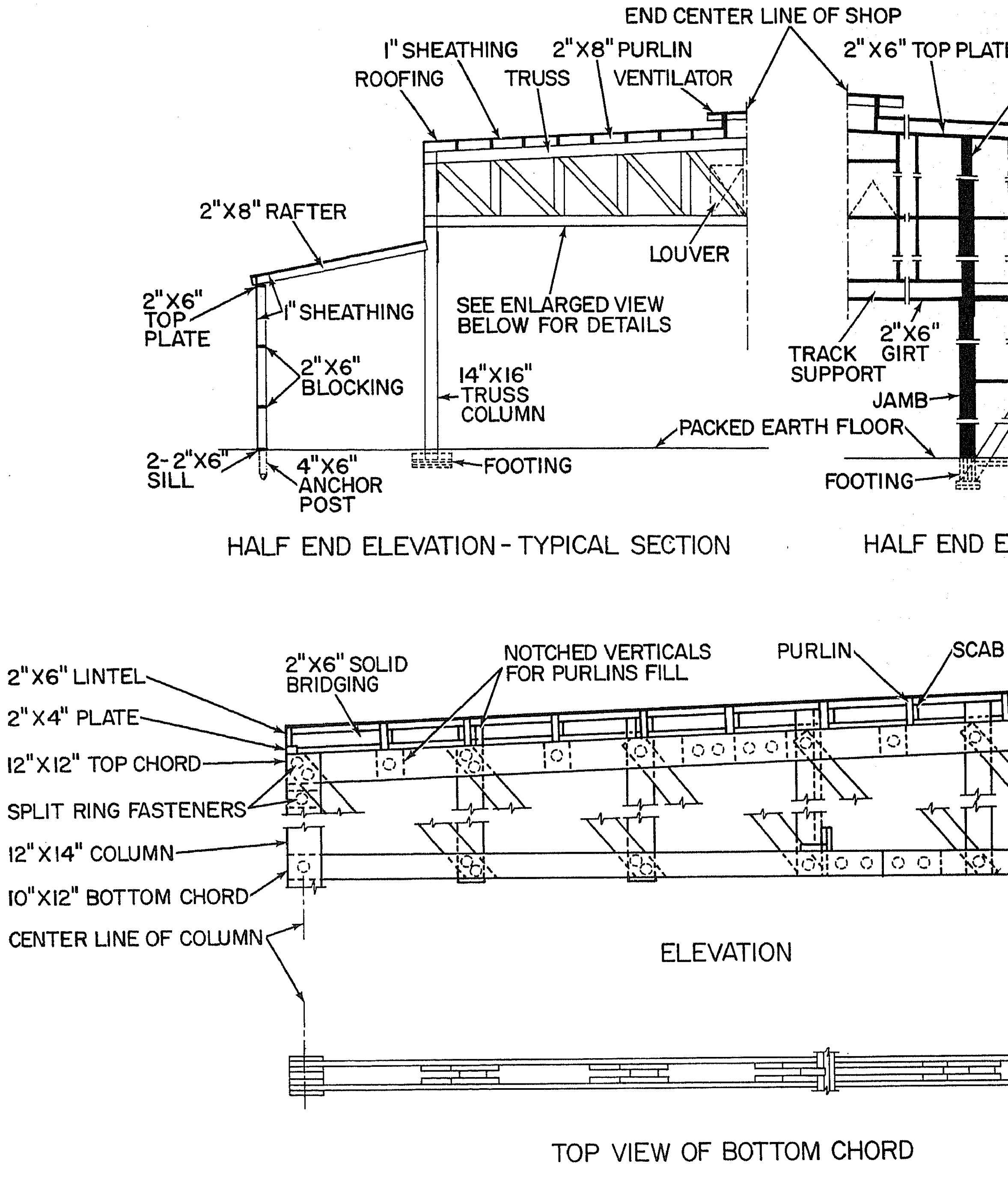


Figure 32. Sectional view of a heavy frame building.

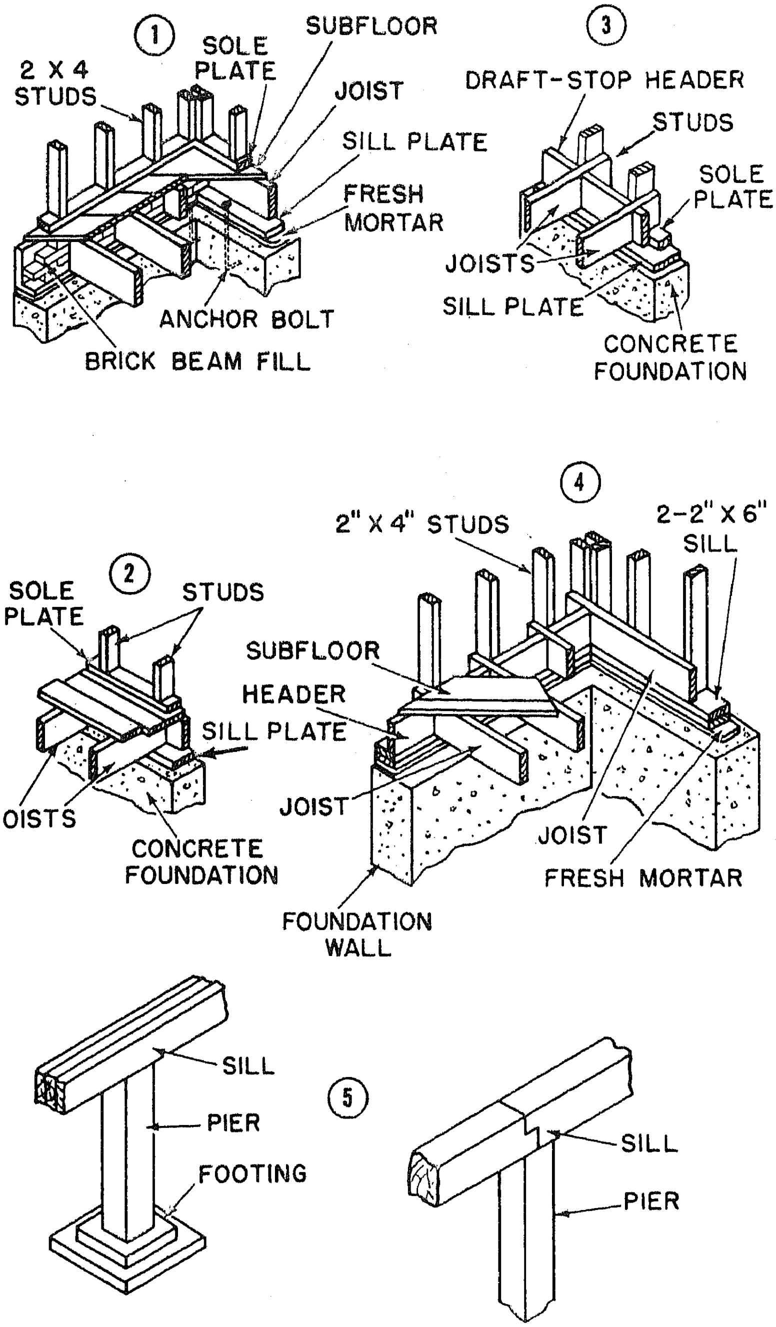


Figure 33. Types of sills.

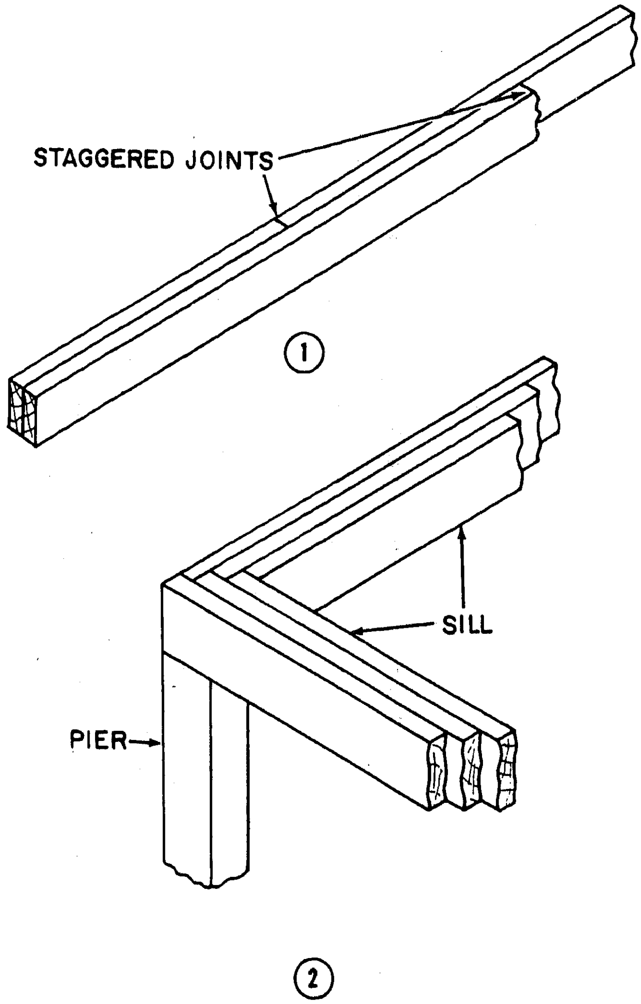


Figure 34. Sill fabrication.

36. Girders

a. Description. Girders are large principal beams used to support floor joists and concentrated loads at particular points along their length. A girder may be either a single beam of a composite section. Girders usually support joists; the girders themselves are supported by columns or bearing walls. When a girder is supported by a wall or pier, it must be remembered that such a girder delivers a large concentrated load to a small section of the wall or pier; therefore, care must be taken to see that such a wall or pier is strong enough in its column action to carry the load imposed upon it by the girder. Girders are needed to support

TABLE XI

SIZES OF BUILT-UP WOOD GIRDERS FOR VARIOUS LOADS AND SPANS

Based on Douglas Fir 4-SQUARE Guide-Line FRAMINIG

Deflection Not Over 1/360 Of Span-Allowable Fiber Stress 1600 lbs. per sq. in.

LOAD PER LINEAR FOOT OF GIRDER	LENGTH OF SPAN				
	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"
	NOMINAL SIZE OF GIRDER REQUIRED				
750	6x8 in.	6x8 in.	6x8 in.	6x10 in.	6x10 in.
900	6x8	6x8	6x10	6x10	8x10
1050	6x8	6x10	8x10	8x10	8x12
1200	6x10	8x10	8x10	8x10	8x12
1350	6x10	8x10	8x10	8x12	10x12
1500	8x10	8x10	8x12	10x12	10x12
1650	8x10	8x12	10x12	10x12	10x14
1800	8x10	8x12	10x12	10x12	10x14
1950	8x12	10x12	10x12	10x14	12x14
2100	8x12	10x12	10x14	12x14	12x14
2250	10x12	10x12	10x14	12x14	12x14
2400	10x12	10x14	10x14	12x14	
2550	10x12	10x14	12x14	12x14	
2700	10x12	10x14	12x14		
2850	10x14	12x14	12x14		
3000	10x14	12x14			
3150	10x14	12x14			
3300	12x14	12x14			

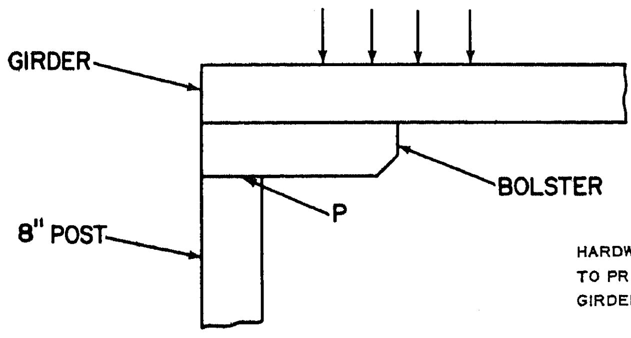
The 6-in. girder is figured as being made with three pieces 2 in. dressed to 1-5/8 in. thickness

The 8-in. girder is figured as being made with four pieces 2 in. dressed to 1-5/8 in. thickness.

The 10-in. girder is figured as being made with five pieces 2-in. dressed to 1-5/8 in. thickness.

The 12-in. girder is figured as being made with six pieces 2 in. dressed to 1-5/8 in. thickness.

Note—For solid girders multiply above loads by 1.130 when 6-inch girder is used; 1.150 when 8-in. girder is used; 1.170 when 10-in. girder is used and 1.180 when 12-in. girder is used.



HARDWOOD BOLSTER USED TO PREVENT CRUSHING OF GIRDER.

wherever the width or length of the building makes
o use joists over the full span. The full span is
e from foundation wall to foundation wall. The
rders is determined by the span and the load to be
XI). In general, the size of a beam or girder varies
quare of the length of the span; thus, if using
which is twice as long as the other, the girder
n should be four times as strong as the girder
n.

. Girders can be built up of wood if select stock
Be sure it is straight and sound. Square off ends
er is to be built up of 2 x 8 or 2 x 10 stock,
awhorses and nail together. Use the piece
least amount of wind or warp for the center
ieces on sides of center stocks. Use a com-
through the first piece and nearly through
are off the ends of the girder after the pieces
ether. If the stock is not long enough to build
ntire length, the pieces must be built up by
joints (1, fig. 35). Girders are often built up by
more joists side by side and nailing them together.
of two members, 16-penny nails should be used; and
rders of four or more members, 20- or 30-penny nails should
be used. The nails must be placed about ½ inch from the top and bottom edges of the joists, spaced about 24 inches apart, and staggered; they should be driven from both sides of the girder alternately. If the girder supporting post is to be built up, it is to be done in the same manner as described for the girder. If the girder is solid or built up, safe sizes are as follows:

Span	*Width*	*Depth*	*Load*
10′	4″	8″	1,988 lb
6′	4″	8″	2,488 lb

37. Floor Joists

Joists are the pieces which make up the body of the floor frame. The flooring or subflooring is nailed to them. They are usually 2 or 3 inches thick and the depth is varied to suit the conditions. Joists as small as 2 by 6 inches are sometimes used in light buildings, but these are too small for floors with spans over 10 feet, though they are frequently used for ceiling joists. Joists usually carry a uniform load of materials and personnel. The latter loads are commonly termed "live loads"; the weight of joists and floors is called a "dead load". The joists carry the flooring directly on their upper surface and they are supported at their ends by sills,

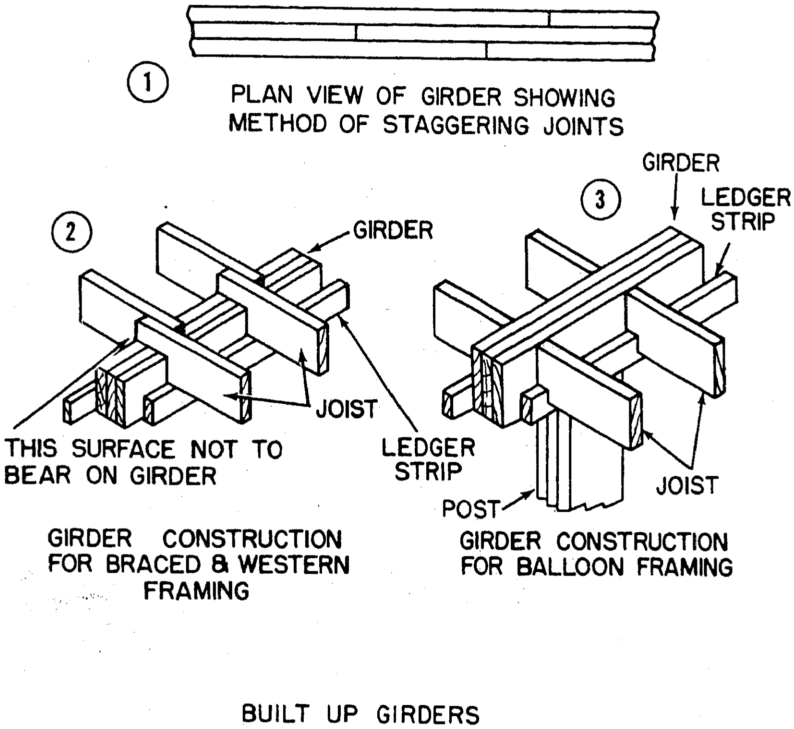


Figure 35. Built up girders.

girders, bearing partitions, or bearing walls (fig. 36). They are spaced 16 or 24 inches apart, center to center; sometimes the spacing is 12 inches, but where such spacing is necessary, heavier joists should be used. Two inch material should not be used for joists more than 12 inches apart.

38. Method of Connecting Joists To Sills, Girders, and I-Beams

Joists are connected to sills and girders by several methods. In modern construction, the method that requires the least time and labor and yet gives the maximum efficiency is used. The same rule is followed in the theater of operations.

a. Sills. In joining joists to sills, always be sure that the connection is able to hold the load that the joists will carry. A joist resting upon the sill is shown in 1, figure 37. This method is the most commonly used because it gives the strongest possible joint. The methods shown in 2 and 3, figure 37, are used where it is not desirable to use joists on top of the sill. The ledger plate (*e* below) should be securely nailed and the joist should not be notched over one-third of its depth to prevent splitting (4, fig. 37). There

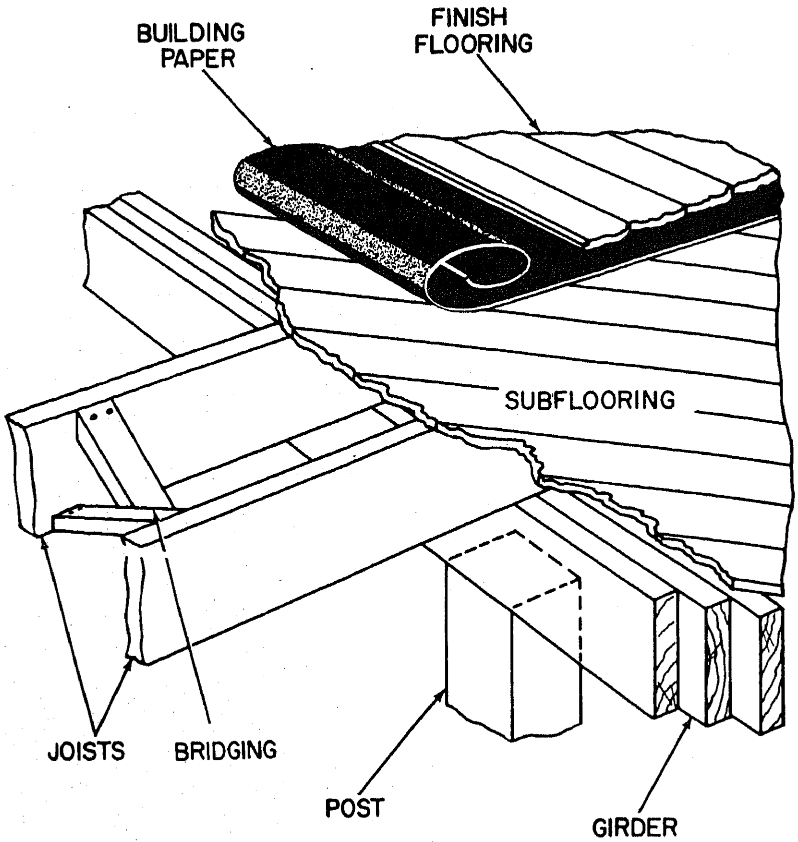


Figure 36. Floor joists.

are several other methods, but those mentioned above are more or less standard. Time, labor, and material are of vital importance and should be kept in mind when determining the method to be used.

b. Girders. The framing of the joists to the girders may be accomplished in several ways, depending upon the position of the girder. The placing of the girders is an important factor. The joists must be level; therefore, if the girder is not the same height as the sill, the joist must be notched as shown in 3, figure 37. If the girder and sill are of the same height, the joist still must be connected to the sill and girder to keep the joist level. In placing joists, always have the crown up since this counteracts the weight on the joist; in most cases there will be no sag below a straight line. Overhead joists are joined to plates as shown in 1, figure 38. The inner end of the joist rests on the plates of the partition walls. When a joist is to rest on plates or girders, either the joist is cut long enough to extend the full width of the plate or girder, or it is

cut so as to meet in the center of the plate or girder and is connected with a scab. Where two joist ends lay side by side on a plate, they should be nailed together (1, fig. 38).

c. Iron Stirrups. A method used to rest or notch the joists is by the use of straps or hangers as illustrated in 5, figure 37. This is one of the strongest and best forms of support.

d. I-Beams. The simplest and probably the best way to carry joists on steel girders is to rest them on top, as indicated in 6, figure 37, provided headroom is not unduly restricted. If there is a lack of headroom, use the method shown in 5, figure 37.

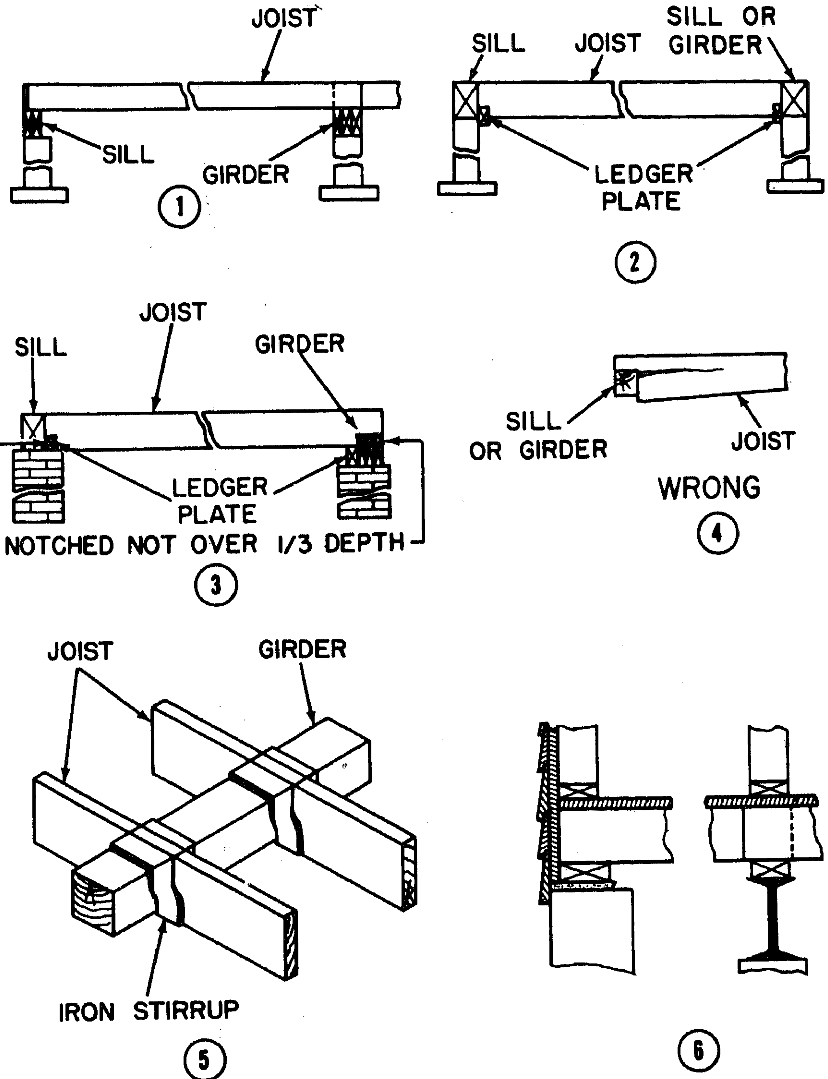


Figure 37. Joist connections.

e. Use of Ledger Plates (fig. 38). In connecting joists to girders and sills where piers are used, a 2 by 4 is nailed to the face of the sill or girder, flush with the bottom edge; this is called a "ledger plate" (1, fig. 38). These pieces should be nailed securely with 20-penny nails about 12 inches apart. Where 2 by 4 or 2 by 8 joists are used, it is better to use 2 by 2's to prevent the joists from splitting at the notch. When joists are 10 inches deep or deeper, 2 by 4's may be used without reducing the strength of the joists. If a notch is used, joist ties may be used to overcome this loss of strength, as shown in figure 38. These ties are short 1 by 4 boards nailed across the joist; the ends of the boards are flush with the top and bottom edge of the joists.

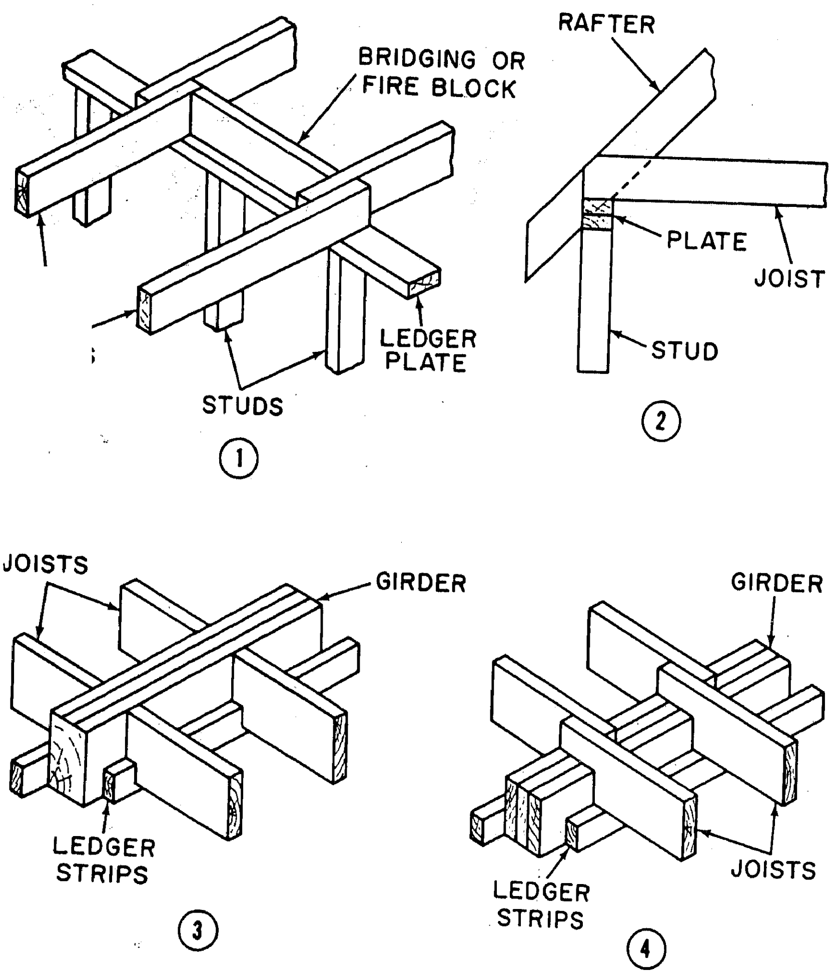


Figure 38. Ledger plates.

39. Bridging

a. General. When joists are used over a long span, they have a tendency to sway from side to side. Floor frames are bridged in order to stiffen the floor frame, to prevent unequal deflection of the joists, and to enable an overload joist to receive some assistance from the joists on either side of it. A pattern for the bridging stock is obtained by placing a piece of material between the joists as shown in figure 39, then mark and saw. When sawed, the cut will form the correct angle. Always nail the top of the bridging with 8- or 10-penny nails. Do not nail the bottom of the bridging until the rough floor has been laid, in order to keep the bridging from pushing up any joist which might cause an unevenne the floor.

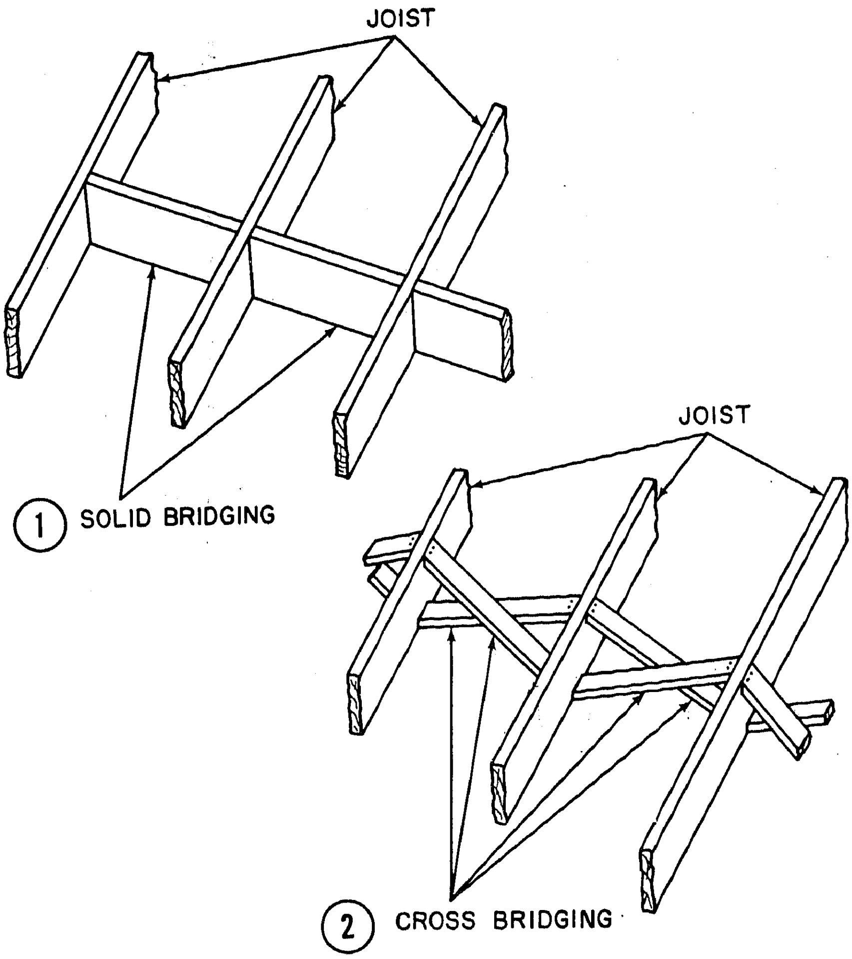


Figure 39. Types of bridging.

b. Construction. Bridging is of two kinds; horizontal bridging (1, fig. 39) and cross bridging (2, fig. 39). Cross bridging is the one most generally used; it is very effective and requires less material than horizontal bridging. Cross bridging looks like a cross and consists of pieces of lumber, usually 1 by 3 or 2 by 3 inches in size, cut in diagonally between the floor joists. Each piece is nailed to the top of each joist and forms a cross between the joists. These pieces between joists should be placed as near to each other as possible. Bridging should be nailed with two 8- or 10-penny nails at each end. The tops should be nailed and the bottoms left until the subfloor is laid. This permits the joists to adjust themselves to their final positions. The bottom ends of bridging may then be nailed, forming a continuous truss across the whole length of the floor and preventing any overloaded joist from sagging below the others. Cutting and fitting the bridging by hand is a slow process; a power saw should be used if it is available. After the joists have once been placed, a pattern may be made and used to speed up the process of cutting. On joists over 8 feet long, one line of bridging should be placed and on joists over 16 feet long, two lines.

Section III. WALLS

40. General

Wall framing (fig. 40) is composed of regular studs, diagonal bracing, cripples, trimmers, headers, and fire blocks and is supported by the floor sole plate. The vertical members of the wall framing are the studs, which support the top plates and all of the weight of the upper part of the building or everything above the top plate line. They provide the framework to which the wall sheathing is nailed on the outside and which supports the lath, plaster, and insulation on the inside.

41. Wall Components

(fig. 41)

Walls and partitions which are classed as framed constructions are composed of structural elements which are usually closely spaced, slender, vertical members called studs. These are arranged in a row with their ends bearing on a long horizontal member called a bottom plate or sole plate, and their tops capped with another plate, called a top plate. Double top plates are used in bearing walls and partitions. The bearing strength of stud walls is determined by the strength of the studs.

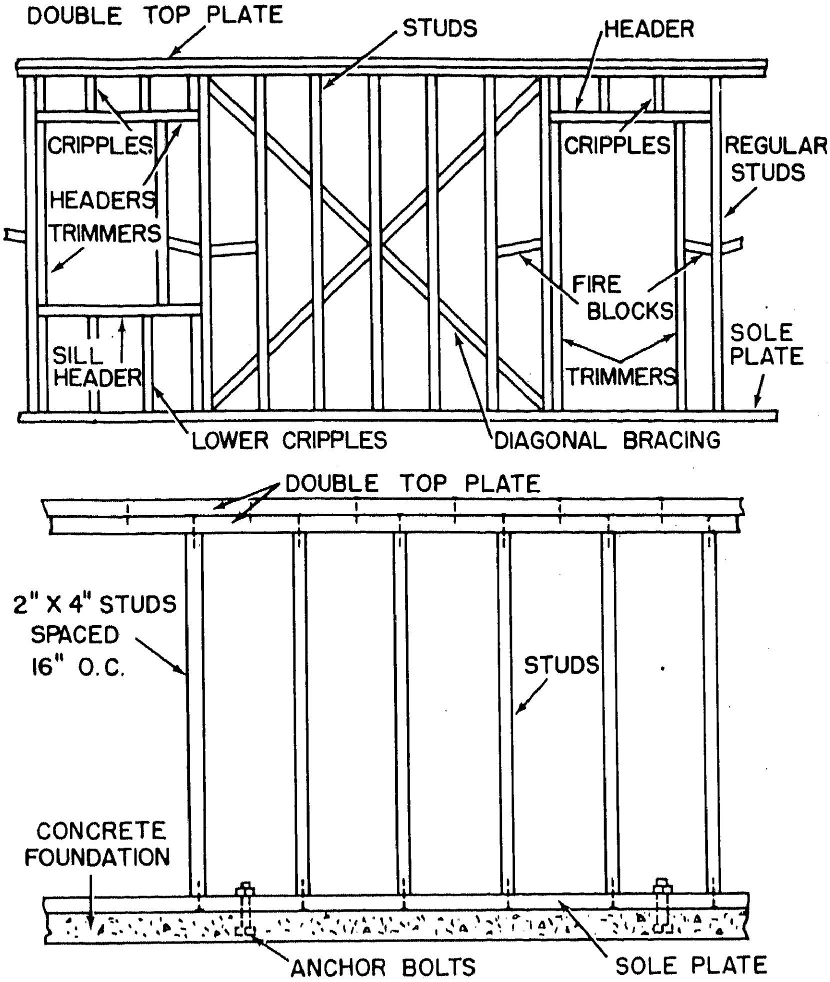


Figure 40. Typical wall frame details.

a. Corner Posts. The studs used at the corners of the frame construction are usually built up from three or more ordinary studs to provide greater strength. These built up assemblies are corner-partition-posts. After the sill and first-floor joists are in place, the first floor is roughly covered to give a surface upon which to work. The corner posts are set up, plumbed, and temporarily braced. The corner posts may be made in several different ways (fig. 42).

(1) A corner post may consist of a 4 by 6 with a 2 by 4 nailed on the board side, flush with one edge. This type or corner is for a 4-inch wall. Where walls are thicker, heavier timber is used.

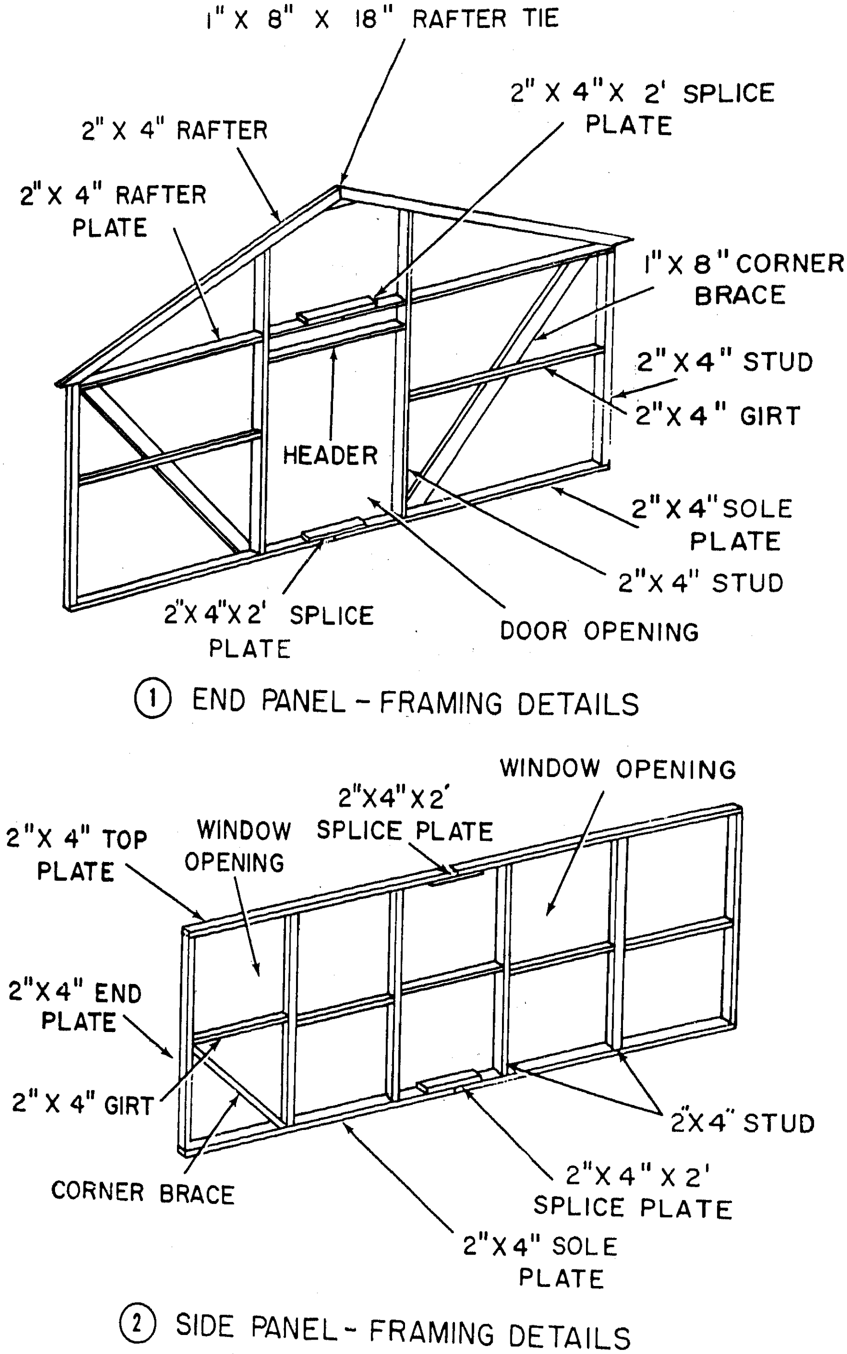


Figure 41. Typical wall construction showing openings.

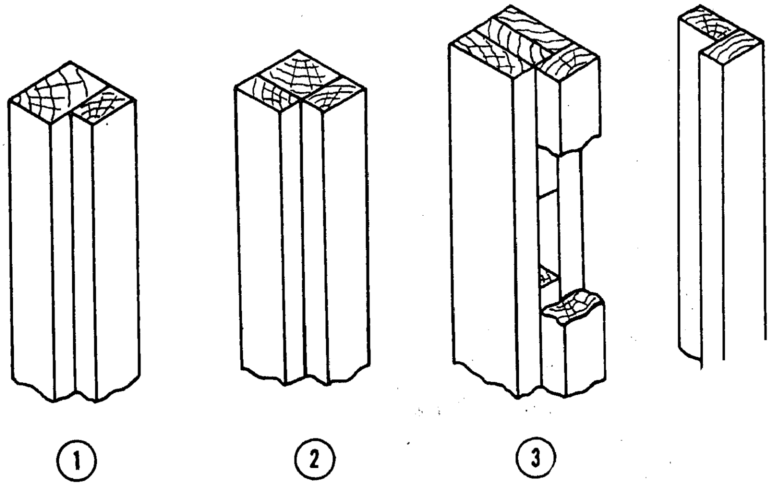


Figure 42. Corner post construction.

(2) A 4 by 4 may be used with a 2 by 4 nailed to two adjoining sides.

(3) Two 2 by 4's may be nailed together with blocks be and a 2 by 4 flush with one edge.

(4) A 2 by 4 may be nailed to the edge of another 2 by 4, the edge of one flush with the side of the other. This type is used extensively in the theater of operations where no inside finish is required.

b. T-*Posts.* Whenever a partition meets an outside wall, a stud wide enough to extend beyond the partition on both sides is used; this affords a solid nailing base for the inside wall finish. This

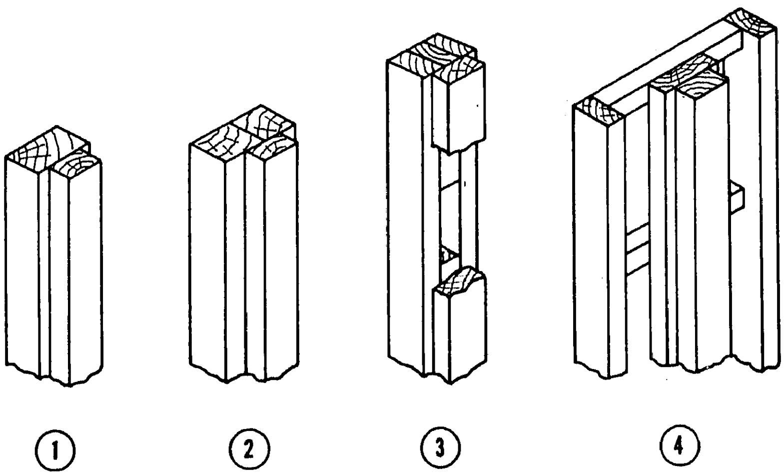


Figure 43. T-*post construction.*

type of stud is called a T-post and is made in several different ways (fig. 43).

(1) A 2 by 4 may be nailed and centered on the face side of a 4 by 6.

(2) A 2 by 4 may be nailed and centered on two 4 by 4's nailed together.

(3) Two 2 by 4's may be nailed together with a block between them and a 2 by 4 centered on the wide side.

4 may be nailed and centered on the face side of 6, with a horizontal bridging nailed behind them support and stiffness.

nd *Double* T-*Posts.* Where a partition is finished he partition post used consists of a simple stud, wall, in line with the side of the partition wall, ud *A* in 1, figure 44. These posts are nailed in th the corner post. The exact position of the partitions must be determined before the posts are placed. Where walls are more than 4 inches thick, wider timber is used. In special cases, for example where partition walls cross, a double T-post is used. This is made by using methods in *b*(1), (2), or (3) above, and nailing another 2 by 4 to the opposite wide side, as shown in 2, 3, and 4, figure 44.

d. Studs.

(1) After the sills, posts, plates, and braces are in place, the studs are placed and nailed with two 16- or 20-penny nails through the top plate. Before the studs are set in place, the window and door openings are laid out. Then the remaining or intermediate studs are laid out on the sills or soles by measuring from one corner the distances the studs are to be set apart. Studs are normally spaced 12, 16, and 24 inches on centers, depending upon the type of building and the type of outside and inside finish. Where vertical siding is used, studs are set wider apart since the horizontal girts between them afford nailing surface.

(2) When it is desirable to double the post of the door opening, first place the outside studs into position and nail them securely. Then cut short studs, or *filler studs,* the size of the opening, and nail these to the inside face of the outside studs as shown in figure 45. In making a window opening, a bottom header must be framed; this header is either single or double. When it is doubled, the

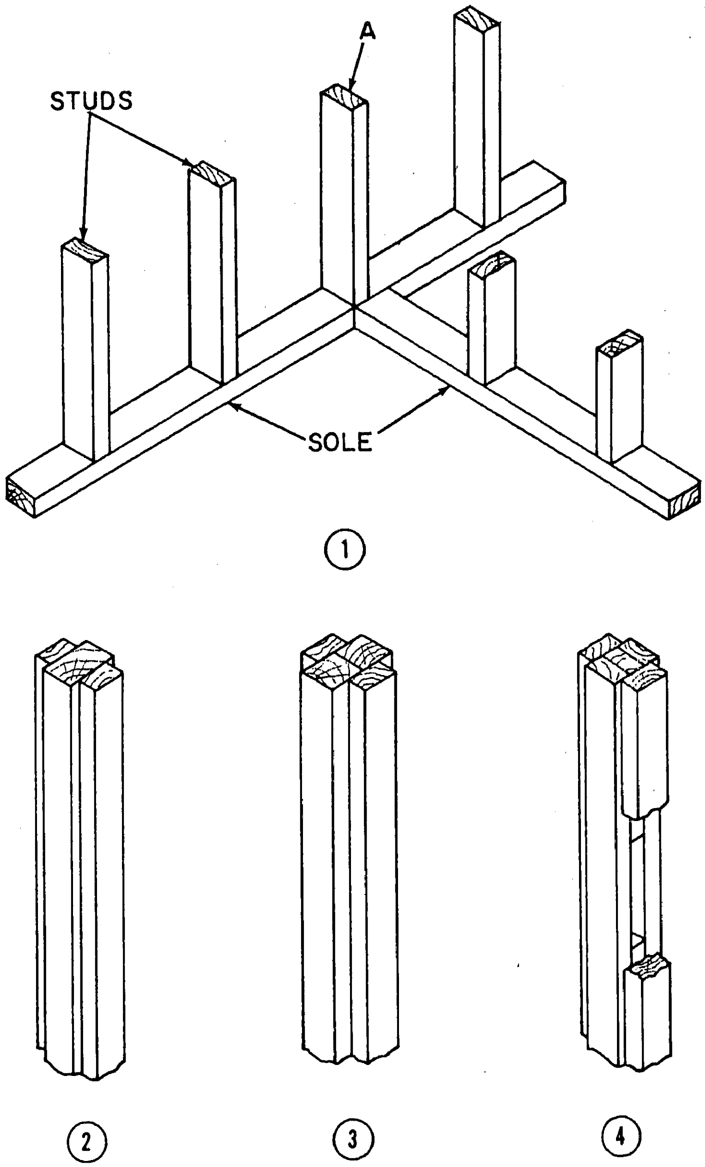


Figure 44. Partition posts.

bottom piece is nailed to the opening studs at the proper height and the top piece of the bottom header is nailed into place flush with the bottom section. The door header is framed as shown in figure 45. The filler stud rests on the sole at the bottom.

e. Girts. Girts are always the same width as the studs and are flush with the face of the stud, both outside and inside. Girts are

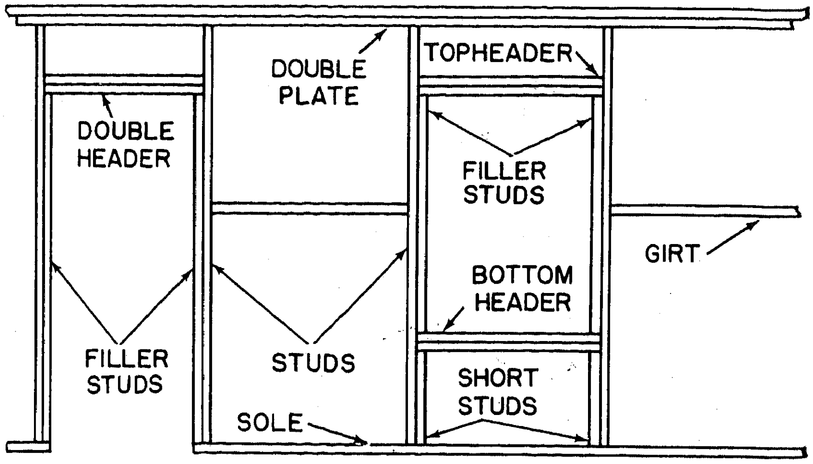


Figure 45. Door and window framing.

used in hasty construction where the outside walls are covered with vertical siding. Studs are placed from 2 to 10 feet apart, with girts, spaced about 4 feet apart, running horizontally between them (fig. 45). The vertical siding acts in the same manner as do studs and helps to carry the weight of the roof. This type of construction is used extensively in the theater of operations.

f. Top Plate and Sole Plate.

(1) *Top plate.* The top plate serves two purposes—to tie the studding together at the top and form a finish for the walls; and to furnish a support for the lower ends of the rafters (fig. 40). The top plate serves as a connecting link between the wall and the roof, just as the sills and girders are connecting links between the floors and the walls. The plate is made up of one or two pieces of timber of the same size as the studs. In cases where the studs at the end of the building extend to the rafters, no plate is used at the end of the building. When it is used on top of partition walls, it is sometimes called the cap. Where the plate is doubled, the first plate or bottom section is nailed with 16- or 20-penny nails to the top of the corner posts and to the studs; the connection at the corner is made as shown in 1, figure 46. After the single plate is nailed securely and the corner braces are nailed into place, the top part of the plate is then nailed to the bottom section by means of 16- or 20-penny nails either over each stud, or spaced with two nails every 2 feet. The edges of the top section should be flush with

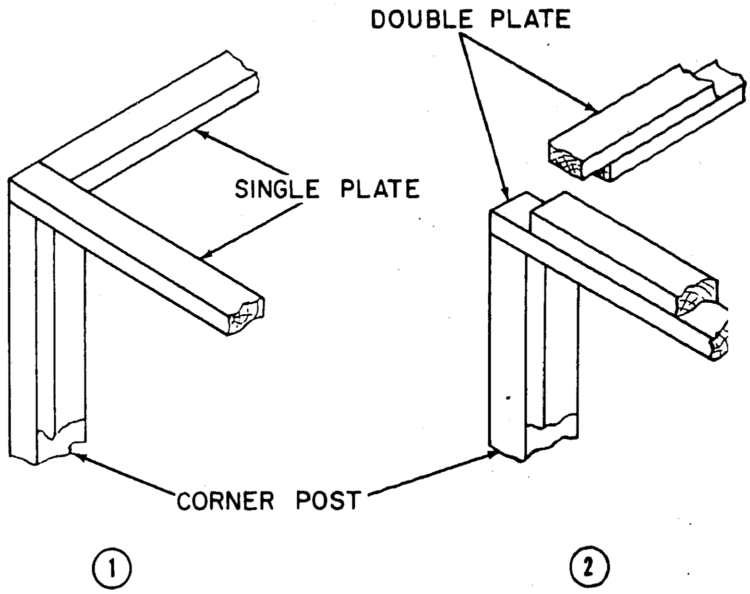


Figure 46. Plate construction.

the bottom section and the corner joints lapped as shown in 1 and 2, figure 46.

(2) *Sole plate.* All partition walls and outside walls are finished either with a 2 by 4 or with a piece of timber corresponding to the thickness of the wall; this timber is laid horizontally on the floor or joists. It carries the bottom end of the studs (fig. 40). This 2 by 4, or timber, is called the "sole" or "sole plate." The sole should be nailed with two 16- or 20-penny nails at each joist that it crosses. If it is laid lengthwise on top of a girder or joist, it should be nailed with two nails every 2 feet.

g. Bridging. Frame walls are bridged, in most cases, to make them more sturdy. There are two methods of bridging—

(1) *Diagonal bridging.* Diagonal bridging is nailed between the studs at an angle (1, fig. 47). It is more effective than the horizontal type since it forms a continuous truss and tends to keep the walls from sagging. Whenever possible, both interior partitions and exterior walls should be bridged alike.

(2) *Horizontal bridging.* Horizontal bridging is nailed between the studs horizontally and halfway between the sole and the plate (2, fig. 47). This bridging is cut to lengths which correspond to the distance between the studs at

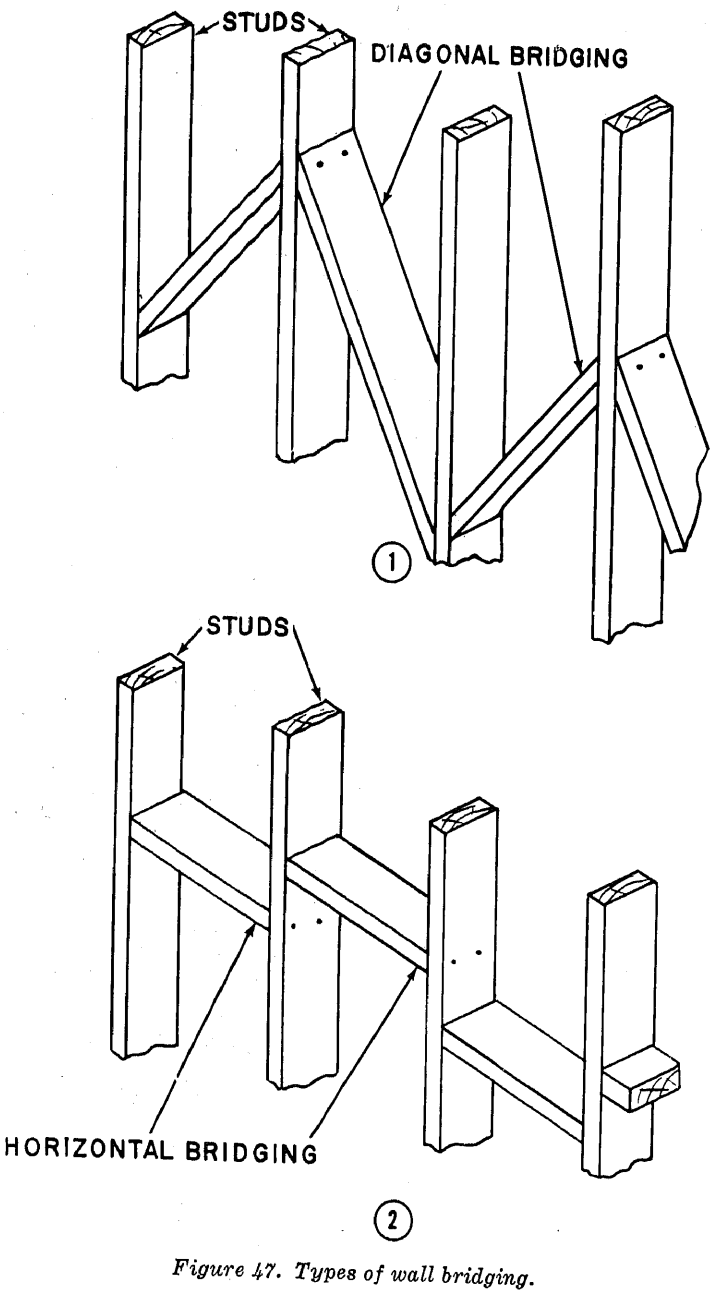


Figure 47. Types of wall bridging.

the bottom. Such bridging not only stiffens the wall but also will help straighten studs.

42. Partitions

Partition walls are any walls that divide the inside space of a building. These walls in most cases are framed as part of the building. In cases where floors are to be installed after the outside of the building is completed, the partition walls are left unframed. There are two types of partition walls: the bearing, and the nonbearing types. The bearing type supports ceiling joists. The nonbearing type supports only itself. This type may be put in at any time after the other framework is installed. Only one cap or plate is used. A sole plate should be used in every case, as it helps to distribute the load over a larger area. Partition walls are framed in the same manner as outside walls, and door openings are framed as outside openings. Where there are corners or where one partition wall joins another, corner posts or T-posts are used as in the outside walls; these posts provide nailing surfaces for the inside wall finish. Partition walls in the theater of operations one-story building may or may not extend to the roof. The top of the studs has a plate when the wall does not extend to the roof; but when the wall extends to the roof, the studs are joined to the rafters.

43. Methods of Plumbing Posts and Straightening Walls

a. General. After the corner post, T-post, and intermediate wall studs have been nailed to the plates or girts, the walls must be plumbed and straightened so that the permanent braces and rafters may be installed. This is done by using a level or plumb bob and a chalkline.

b. Plumbing Posts.

(1) To plumb a corner with a plumb bob, first attach to the bob a string long enough to extend to or below the bottom of the post. Lay a rule on top of the post so that 2 inches of the rule extends over the post on the side to be plumbed; then hang the bob-line over the rule so that the line is 2 inches from the post and extends to the bottom of it, as shown in 1, figure 48. With another rule, measure the distance from the post to the center of the line at the bottom of the post; if it does not measure 2 inches, the post is not plumb. Move the post inward or outward until distance from the post to the center of the

line is exactly 2 inches. Then nail the temporary brace in place. Repeat this procedure from the other outside face of the post. The post is then plumb. This process is carried out for the remaining corner posts of the building. If a plumb bob or level is not available, a rock, a half-brick, or some small piece of metal may be used instead.

(2) An alternate method of plumbing a post is illustrated in 2, figure 48. Attach the plumb bob string securely to the top of the post to be plumbed, making sure that the string is long enough to allow the plumb bob to hang near the bottom of the post. Use 2 blocks of wood identical in

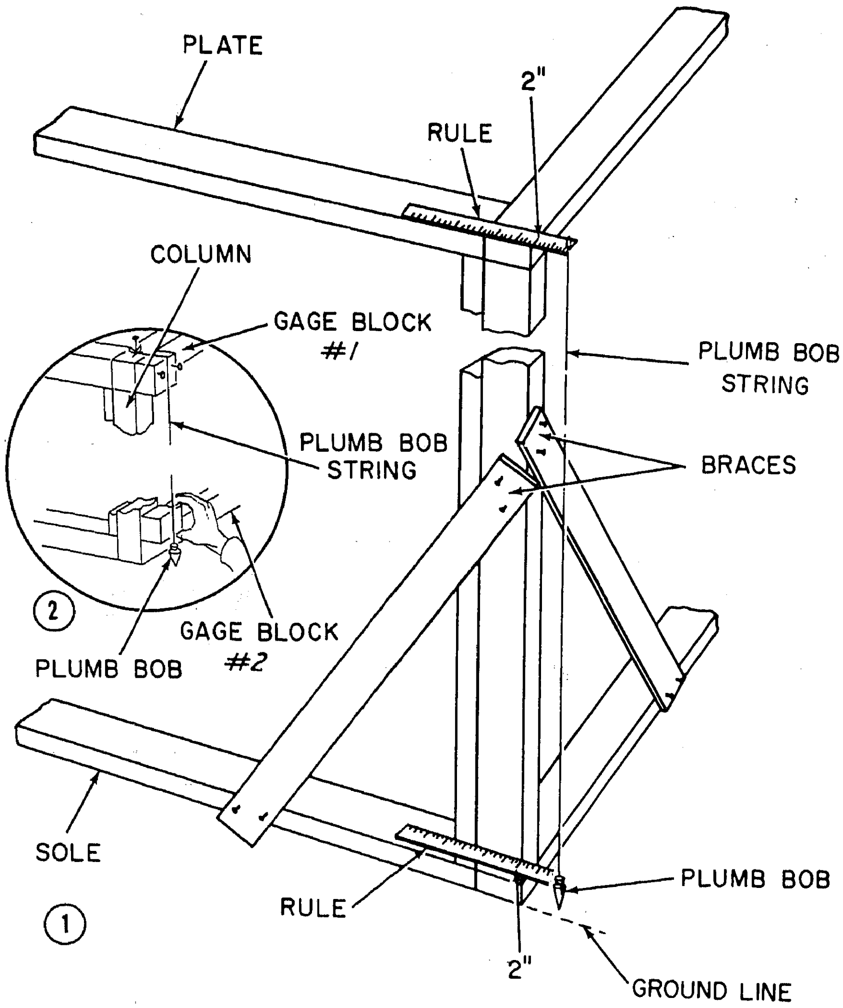


Figure 48. Method of plumbing posts.

thickness as gage blocks. Tack one block near the top of the post between the plumb bob string and the post (gage block No. 1), inserting the second block between the plumb bob string and the bottom of the post (gage block No. 2). If the entire face of the second block makes contact with the string, the post is plumb.

c. Straightening Walls (fig. 49). Plumb one corner post with the level or plumb bob and nail temporary braces to hold the post in place (*b* above). Repeat this procedure for all corner posts. Fasten a chalkline to the outside of one post at the top and stretch the line to the post at the opposite end of the building, fastening the line to this post in the same manner as for the first post. Place a small $\frac{3}{4}$-inch block under each end of the line as shown in figure 49 to give clearance. Place temporary braces at intervals small enough to hold the wall straight. When the wall is far enough away from the line to permit a $\frac{3}{4}$-inch block to barely slide between the line and the plate, the brace is nailed. This procedure is carried out for the entire perimeter of the building. Inside partition walls should be straightened in the same manner.

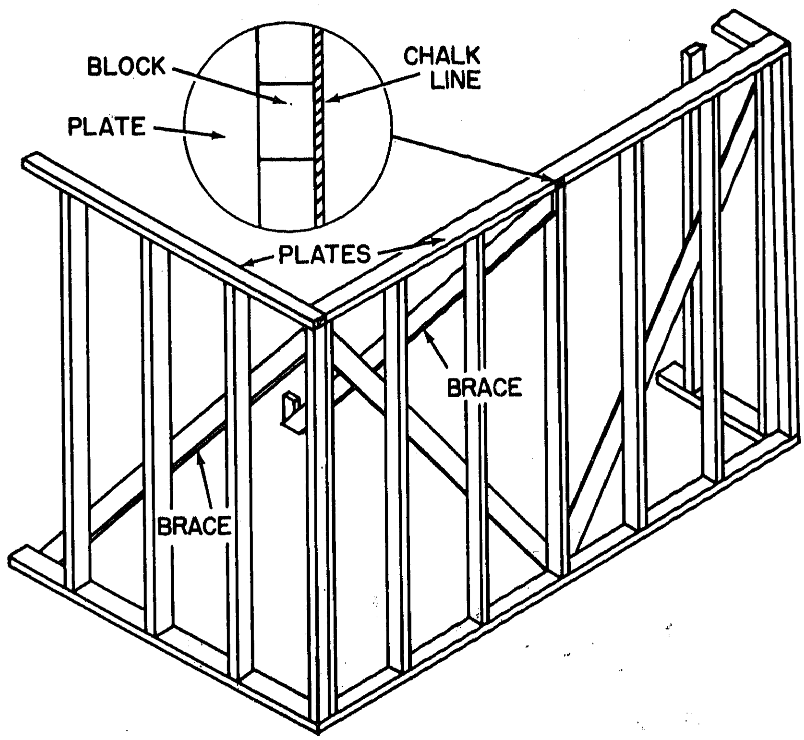


Figure 49. Method of straightening walls.

44. Braces

a. General. Bracing is used to stiffen framed construction and make it rigid. The purpose of bracing may be to resist winds, storm, twist, or strain stemming from any cause. Good bracing keeps corners square and plumb and prevents warping, sagging, and shifts resulting from lateral forces that would otherwise tend to distort the frame and cause badly fitting doors and windows and the cracking of plaster.

b. Construction. There are three commonly used methods of bracing frame structures.

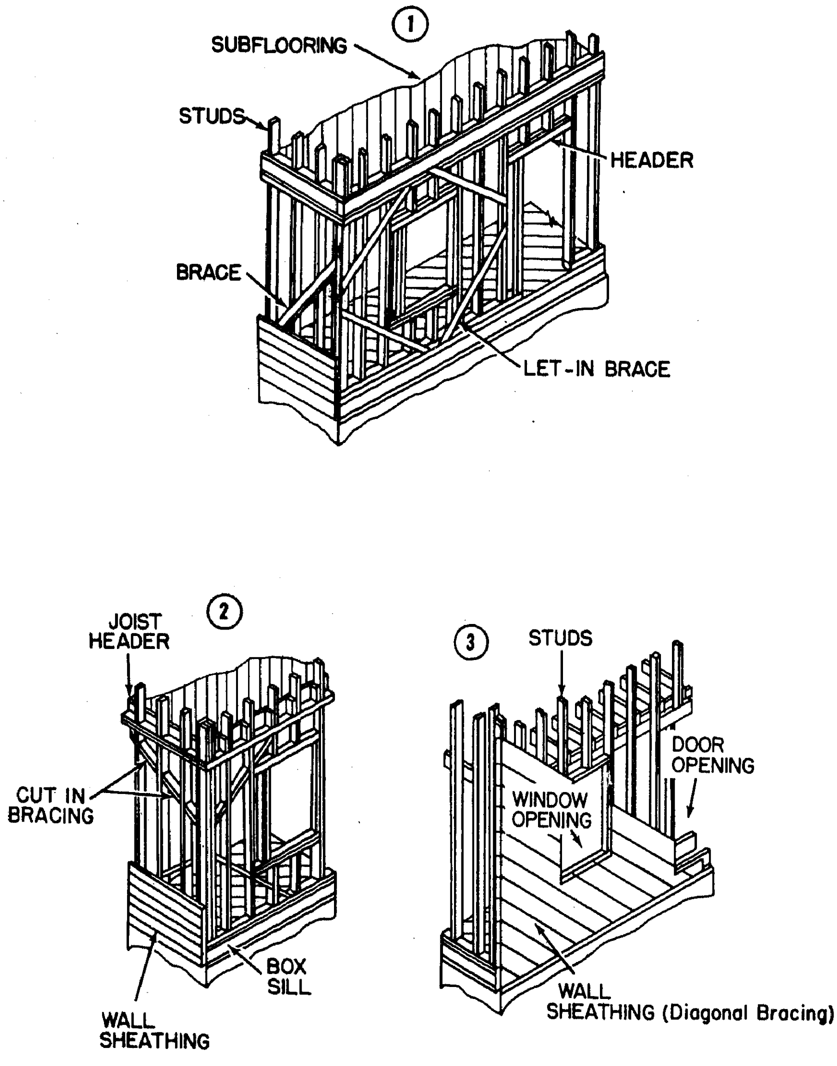


Figure 50. Common types of bracing.

(1) *Let-in bracing* (1, fig. 50). Let-in bracing is set into the edges of studs so as to be flush with the surface. studs are always cut to let in the braces; the brace never cut. Usually 1 by 4's or 1 by 6's are used diagonally from top plates to sole plates.

(2) *Cut-in bracing* (2, fig. 50). Cut-in bracing is between studs. It usually consists of 2 by 4's c angle to permit toenailing, inserted in diago gression between studs running up and down fro posts to sill or plates.

(3) *Diagonal sheathing* (3, fig. 50). The type o the highest strength is sheathing applie Each board acts as a brace of the wall. If pl ing ⅝-inch thick or more is used, other me ing may be omitted.

Section IV. CEILING AND ROOF

45. Ceilings

Ceiling joists carry the weight of the plaster and form the ceiling of the room. Usually lighter than floor joists, they must be large enough and strong enough to resist bending and buckling, to remain rigid, and to prevent cracking of the plaster. Ceiling joists are generally installed 16 inches apart on centers. Spacing starts at one side of the building and is carried across the structure. Extra joists, if needed, may be placed without affecting the spacing of the prime joists. Ceiling joists are installed in much the same way as floor joists. Their length is determined in the same way as floor joists. They are located parallel with the rafters and extend in a continuous line across the structure. Nail ceiling joists to both the plates and the rafters if possible, and lap and spike them over bearing partitions. Joists that lie beside rafters on a plate are cut at a slope corresponding to the pitch of the rafter, flush with the top of the rafter. They are installed crown or camber up. For details, see figure 51.

46. Roofs

a. General. The primary object of a roof in any climate is to keep out the rain and the cold. The roof must be sloped so as to shed water. Where heavy snows cover the roofs for long periods of time, roofs must be constructed more rigidly to bear the extra weight. They must also be strong enough to withstand high winds. The most commonly used types of roof construction include—

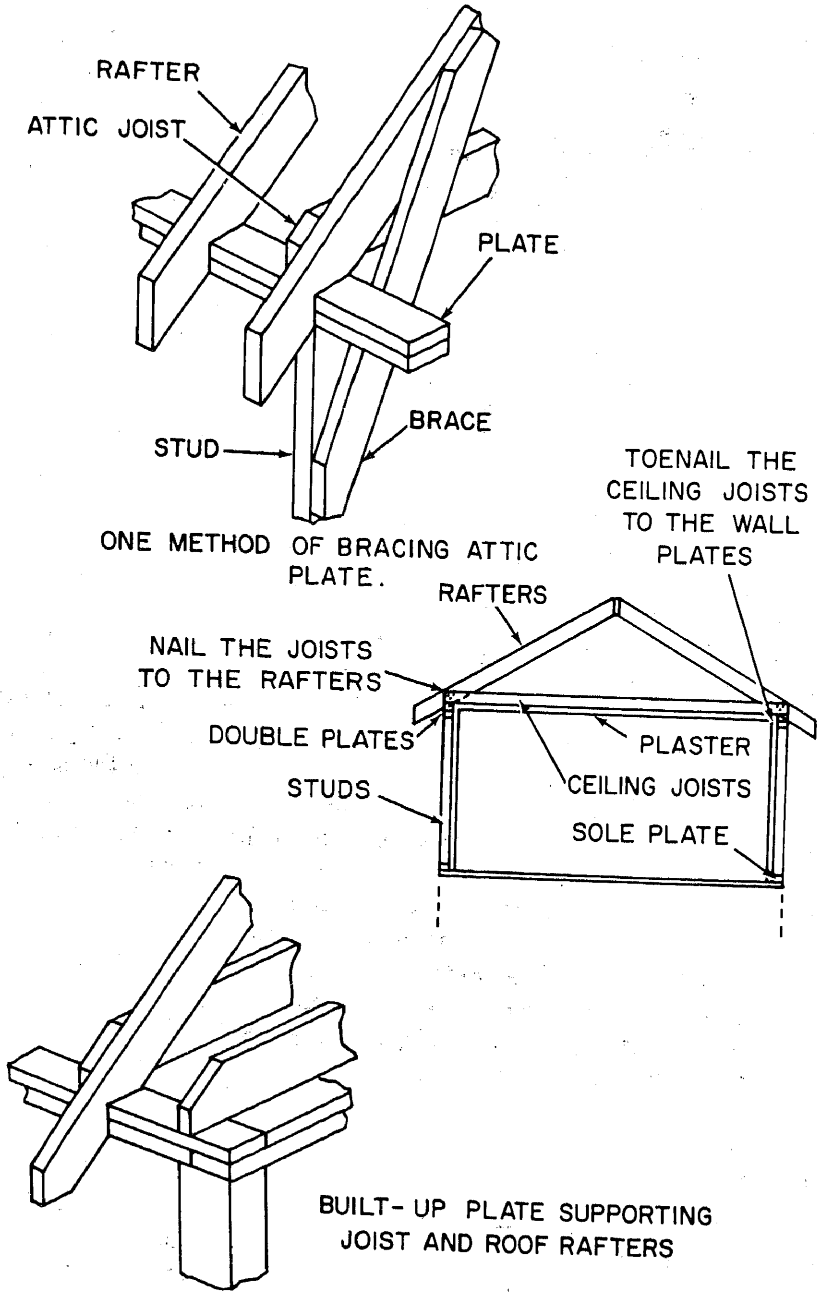


Figure 51. Ceiling joists.

(1) *Gable roof* (1, fig. 52). The gable roof is the most commonly used of the various types of roofs. It has tw roof slopes meeting at the center, or ridge, to form a gable. This form of roof is the one most commonly used by the Army, since it is simple in design, economical t construct, and may be used on any type structure.

(2) *Lean-to or shed roof* (2, fig. 52). This near-flat roof i used where large buildings are framed under one roof, where hasty or temporary construction is neede where sheds or additions to buildings are er pitch of the roof is in one direction only. The up by the walls or posts on four sides; one posts on one side are at a higher level than th opposite side.

(3) *Hip roof* (3, fig. 52). The hip roof consist or slopes running toward the center of Rafters at the corners extend diagonally center, or ridge. Into these rafters, other framed.

(4) *Gable and valley roof* (4, fig. 52). This roof is a nation of two gable roofs intersecting each other valley is that part where the two roofs meet, eac slanting in a different direction. This type of r seldom used, since it is complicated and requires time and labor to construct.

b. Pitch of Roofs. The pitch or "slope" of a roof is the angle which the roof surface makes with a horizontal plane. The surface may vary from absolutely flat to a steep slope. The usual way to express roof pitch is by means of numbers; for example, 8 and 12, 8 being the rise and 12 the run. On drawings, roof pitch is shown as in figure 53.

c. Terms Used in Connection With Roofs.

(1) *Span.* The span (1, fig. 54) of any roof is the shortest distance between the two opposite rafter seats. Stated in another way, it is the measurement between the outside plates, measured at right angles to the direction of the ridge of the building.

(2) *Total rise.* The total rise (1, fig. 54) is the vertical distance from the plate to the top of the ridge.

(3) *Total run.* The term "total run" (1, fig. 54) always refers to the level distance over which any rafter passes. For the ordinary rafter, this would be one-half the span distance.

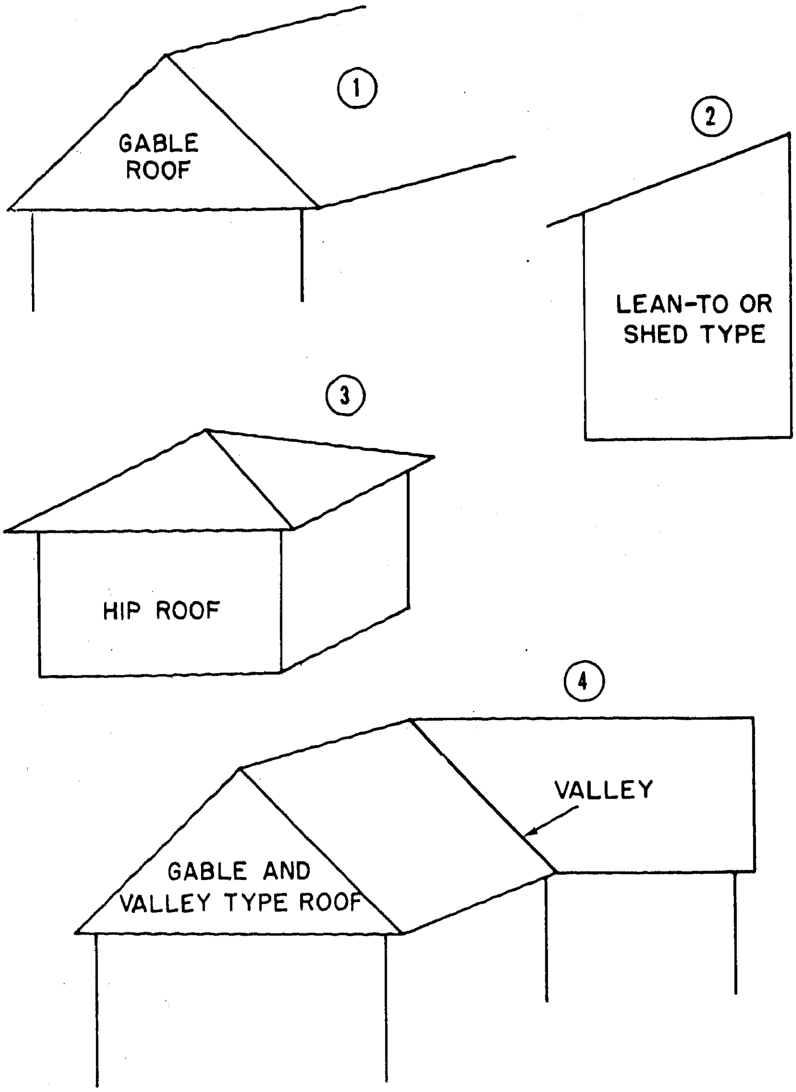


Figure 52. Types of roofs.

(4) *Unit of run.* The unit of measurement, 1 foot or 12 inches is the same for the roof as for any other part of the building. By the use of this common unit of measurement, the framing square is employed in laying out large roofs (1 and 2, fig. 54).

(5) *Rise in inches.* The rise in inches is the number of inches that a roof rises for every foot of run.

(6) *Pitch.* Pitch is the term used to describe the amount of slope of a roof (2, fig. 54).

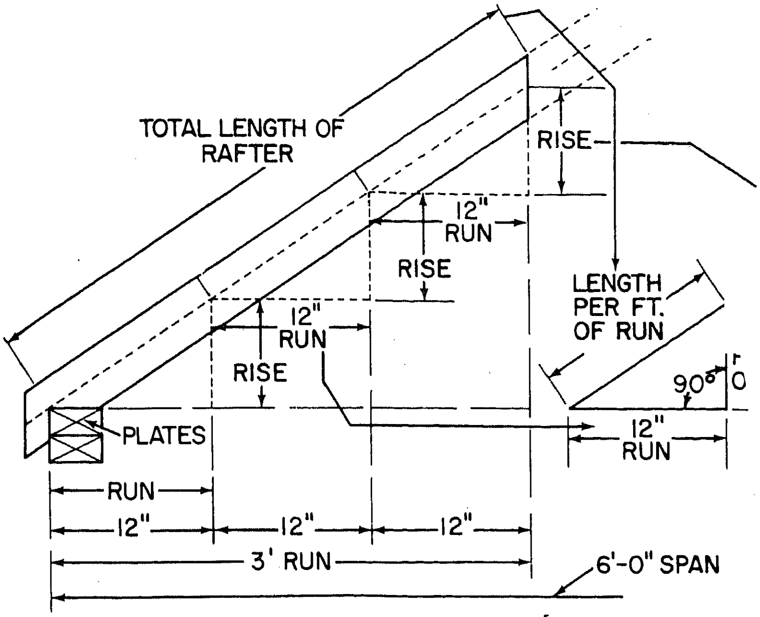


Figure 53. Roof pitch.

(7) *Cut of roof.* The cut of a roof is the rise in inches and the unit of run (12 inches) (2, fig. 54).

(8) *Line length.* The term "line length" as applied to roof framing is the hypotenuse of a triangle whose base is the total run and whose altitude is the total rise (1, fig. 54).

(9) *Plumb and level lines.* These terms have reference to the direction of a line on a rafter and not to any particular rafter cut. Any line that is vertical when the rafter is in its proper position is called a plumbline. Any line that is level when the rafter is in its proper position is called a level line (3, fig. 54).

47. Rafters

a. General. The pieces which make up the main body of the framework of all roofs are called rafters. They do for the roof what the joists do for the floor and what the studs do for the wall. Rafters are inclined members spaced from 16 to 48 inches apart which vary in size, depending on their length and the distance at which they are spaced. The tops of the inclined rafters are fastened in one of the various common ways determined by the type of roof. The bottoms of the rafters rest on the plate member which provides a connecting link between wall and roof and is really a functional

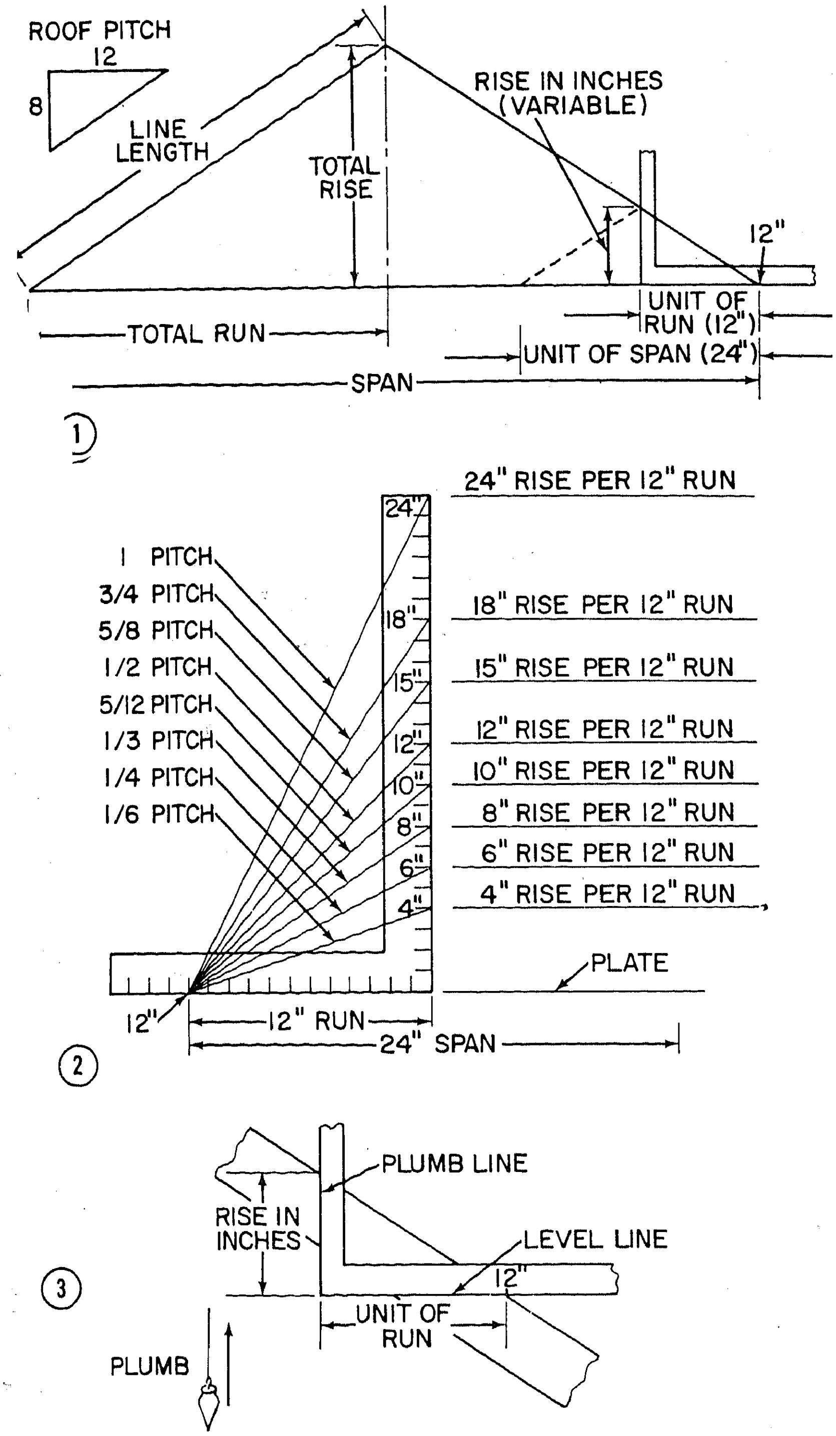


Figure 54. Roof terms.

part of both. The structural relationship between rafters and wall is the same in all types of roofs. The rafters are not framed into the plate but are simply nailed to it, some being cut to fit the plate while others, in hasty construction, are merely laid on top of the plate and nailed in place. Rafters may extend a short distance beyond the wall to form the eaves and protect the sides of the building.

b. Terms. Since rafters, with ridgeboards and plates, are the principal members of roof framing, it is important to understand the following terms that apply to them.

(1) *Common rafters.* The common rafters (1, fig. 55), extend from plate to ridgeboard at right angles to both.

(2) *Hip rafters.* Hip rafters (2, fig. 55), extend diagonally from the corners formed by perpendicular plates to the ridgeboard.

(3) *Valley rafters.* Valley rafters (3, fig. 55), extend from the plates to the ridgeboard along the lines where two roofs intersect.

(4) *Jack rafters.* Jack rafters never extend the full distance from plate to ridgeboard. Jack rafters are subdivided into the hip jacks (4, fig. 55), the lower ends of which rest on the plate and the upper ends against the hip rafter; valley jacks (5, fig. 55), the lower ends of which rest against the valley rafters and the upper ends against the ridgeboard; and cripple jacks, (6, fig. 55), which are nailed between hip and valley rafters.

(5) *Top or plumb cut.* The cut made at the end of the rafter to be placed against the ridgeboard or, if the ridgeboard is omitted, against the opposite rafters.

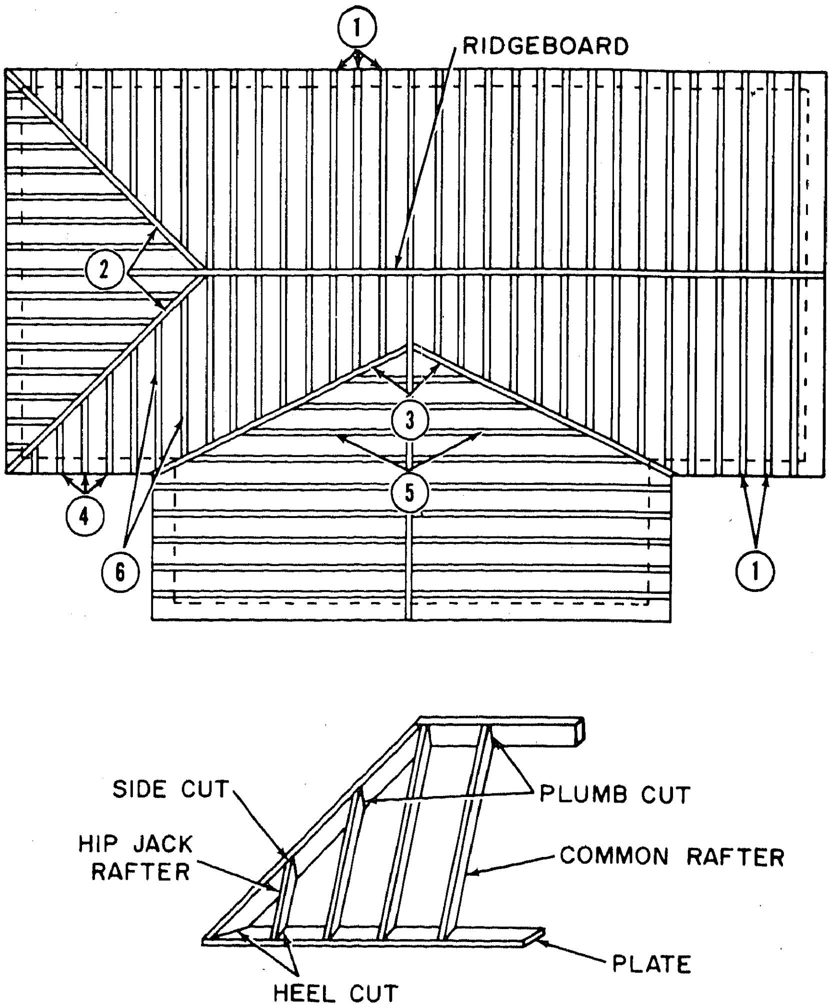
(6) *Seat, bottom, or heel cut.* The cut made at the end of the rafter which is to rest on the plate.

(7) *Side or cheek cut.* A bevel cut on the side of a rafter to fit it against another frame member.

(8) *Rafter length.* The shortest distance between the outer edge of the plate and the center of the ridge line.

(9) *Eave or tail.* The portion of the rafter extending beyond the outer edge of the plate.

(10) *Measure line.* An imaginary reference line laid out down the middle of the face of a rafter. If a portion of a roof is represented by a right triangle (fig. 56), the measure line will correspond to the hypotenuse, the rise to the leg, and the run to the base.



1	Common rafters	4	Hip jacks
2	Hip rafters	5	Valley jacks
3	Valley rafters	6	Cripple jacks

Figure 55. Rafter terms.

48 Rafter Layout

Rafters must be laid out and cut with slope, length, and overhang exactly right so that they will fit when placed in the position they are to occupy in the finished roof.

a. Scale or Measurement Methods. The carpenter first determines the length of the rafter and the length of the piece of lumber from which the rafter may be cut. If he is working from a set of plans which includes a roof plan, the rafter lengths and the width

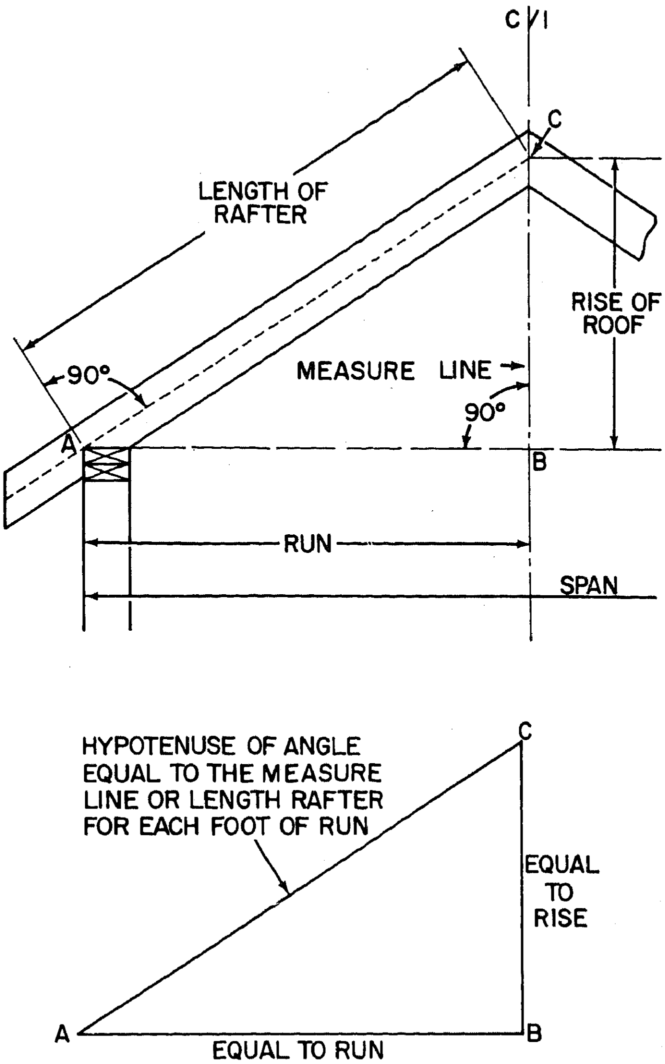


Figure 56. Measure line.

of the building may be obtained from this plan. If no plans are available, the width of the building may be measured with a tape.

(1) To determine the rafter length, first find one-half of the distance between the outside plates. This distance is the horizontal distance which the rafter will cover. The amount of rise per foot has yet to be considered. If the building to be roofed is 20 feet wide, half the span will be 10 feet. For example, the rise per foot is to be 8 inches. To determine the approximate overall length of

a rafter, measure on the steel carpenter square the distance between 8 on the tongue and 12 on the blade, because 8 is the rise and 12 is the unit of run. This distance is $14\frac{5}{12}$ inches, and represents the line length of a rafter with a total run of 1 foot and a rise of 8 inches. Since the run of the rafter is 10 feet, multiply 10 by the line length for 1 foot. The answer is $144\frac{2}{12}$ inches, or 12 feet and $\frac{1}{6}$ inch. The amount of overhang, normally 1 foot, must be added if an overhang is to be used. This makes a total of 13 feet for the length of the rafter, but since 13 feet is an odd length for timber, a 14-foot timber is used.

(2) After the length has been determined, the timber is laid on sawhorses, sometimes called "saw benches", with the crown or bow (if any) as the top side of the rafter. If possible, select a straight piece for the pattern rafter. If a straight piece is not available, have the crown toward the person laying off the rafter. Hold the square with the tongue in the right hand, the blade in the left, the heel away from the body, and place the square as near the upper end of the rafter as possible. In this case, the figure 8 on the tongue and 12 on the blade are placed along the edge of timber which is to be the top edge of the rafter as shown in 1, figure 57. Mark along the tongue edge of the square, which will be the plumb cut at the ridge. Since the length of the rafter is known to be 12 feet and $\frac{1}{6}$ inch, measure the distance from the top of the plumb cut and mark it on the timber. Hold the square in the same manner with the 8 mark on the tongue directly over the 12-foot and $\frac{1}{6}$ inch mark. Mark along the tongue of the square to give the plumb cut for the seat (2, fig. 57). Next measure off, perpendicular to this mark, the length of overhang along the timber and make a plumb cut mark in the same manner, keeping the square on the same edge of the timber (3, fig. 57). This will be the tail cut of the rafter; often the tail cut is made square across the timber.

(3) The level cut or width of the seat is the width of the plate, measured perpendicular to the plumb cut, as shown in 4, figure 57. Using the try square, square lines down on the sides from all level and plumb cut lines. Now the rafter is ready to be cut.

b. Step-Off Method. If a building is 20 feet 8 inches wide, the run of the rafter would be 10 feet 4 inches, or half the span. In-

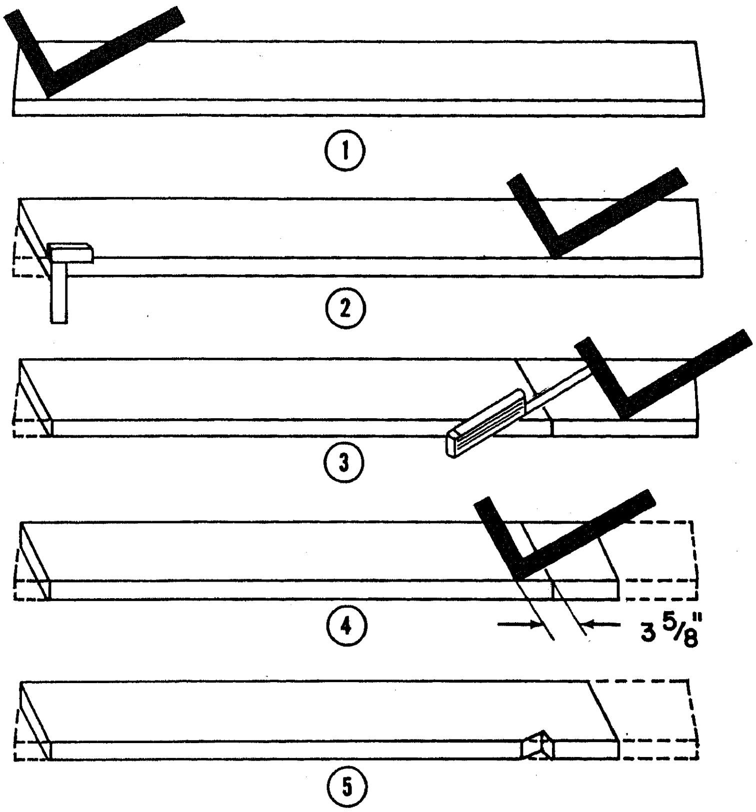


Figure 57. Rafter layout—scale or measurement method.

stead of using the above method, the rafter length may be determined by "stepping it off" by successive steps with the square as shown in figure 58. Stake the same number of steps as there are feet in the run, which leaves 4 inches over a foot. This 4 inches is taken care of in the same manner as the full foot run; that is, with the square at the last step position, make a mark on the rafters at the 4-inch mark on the blade, then move the square along the rafter until the tongue rests at the 4-inch mark. With the square held for the same cut as before, make a mark along the tongue. This is the line length of the rafter. The seat-cut and hangover are made as described in *a* above. When laying off rafters by any method, be sure to recheck the work carefully. When two rafters have been cut, it is best to put them in place to see if they fit. Minor adjustments may be made at this time without serious damage or waste of material.

c. Table Method, Using Rafter Table on Framing Square. The framing square may have one or two types of rafter tables on the

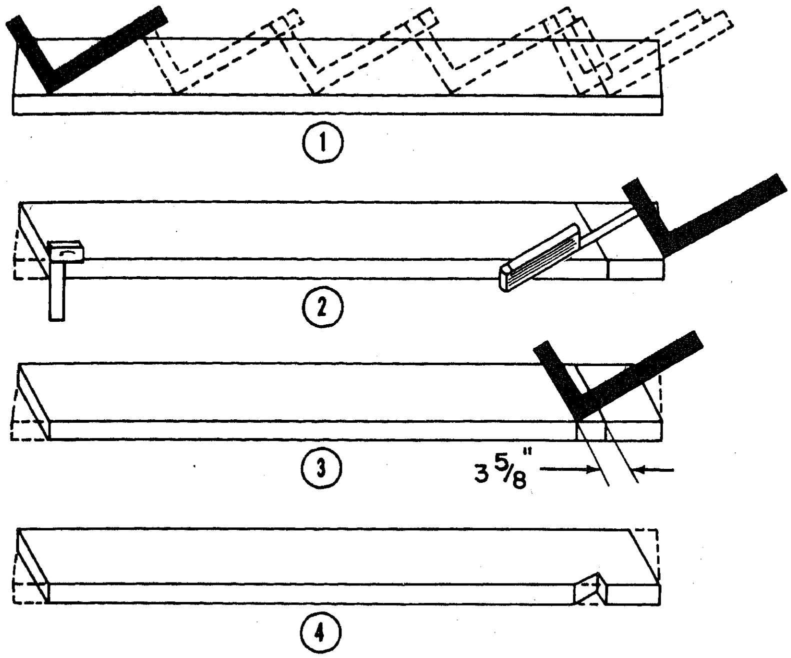


Figure 58. Rafter layout—step-off method.

blade. One type gives both the line length of any pitch or rafter per foot of run and the line length of any hip or valley rafter per foot of run. The difference in length of the jack rafter spaced 16 or 24 inches (on center) is also shown in the table. Where the jack rafter, hip, or valley rafter requires side cuts, the cut is given in the table. The other type of table gives the actual length of rafter for a given pitch and span.

(1) The first type of table (fig. 59) appears on the face of the blade. It is used to determine the length of the common, valley, hip, and jack rafters, and the angles at which they must be cut to fit at the ridge and plate. To use the table, the carpenter first must become familiar with it and know what each figure represents. The row of figures in the first line represents the length of common rafters per foot of run, as the title indicates at the lefthand end of the blade. Each set of figures under each inch division mark represents the length of rafter per foot of run with a rise corresponding to the number of inches over the number. For example, under the 16-inch mark appears the number 20.00 inches. This number equals the length of a rafter with a run of 12 inches and a rise of 16 inches, or, under the 13-inch mark appears the number 17.69 inches which

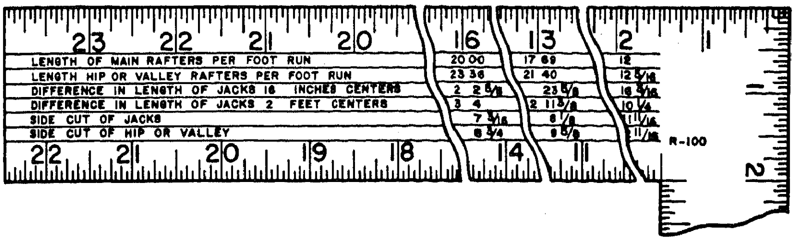


Figure 59. Rafter table method (type 1).

is the rafter length for a 12-inch run and a 13-inch rise. The other five lines of figures in the table will not be discussed as they are seldom used in the theater of operations.

(2) To use the table for laying out rafters, the width of the building must first be known. Suppose the building is 20 feet 8 inches wide and the rise of the rafters is to be 8 inches per foot of run. The total run of the rafter will be 10 feet 4 inches. Look in the first line of figures, under the 8-inch mark appears the number 14.42, which is the length in inches of a rafter with a run of 1 foot and a rise of 8 inches. To find the line length of a rafter with a total run of 10 feet 4 inches, multiply 14.42 inches by 10⅓ and divide by 12 so as to get the answer in feet. The 14.42 inches by 10⅓ equals 149.007 inches, which is divided by 12 to equal 12$\frac{5}{12}$ feet. Therefore 12 feet 5 inches is the line length of the rafter. The remaining procedure for laying out the rafters after the length has been determined is described in *a* above.

(3) The second type of rafter table (fig. 60) appears on the back of the blade of some squares. This shows the run rise and the pitch of rafters of the seven most common pitches of roof. The figures are based on the length of the horizontal measurement of the building from the center to the outside. The rafter table and the outside edge of the back of the square, both the body and tongue, are in twelfths. The inch marks may represent inches or feet, and the twelfth marks may represent twelfths of an inch or twelfths of a foot. The rafter table is used in connection with the marks and figures on the outside edge of the square. At the left end of the table are figures representing the *run*, the *rise*, and the *pitch*. In the first column, the figures are all 12. These may be used as 12 inches or 12 feet as they represent the *run* of 12. The second column of figures represents various rises. The third

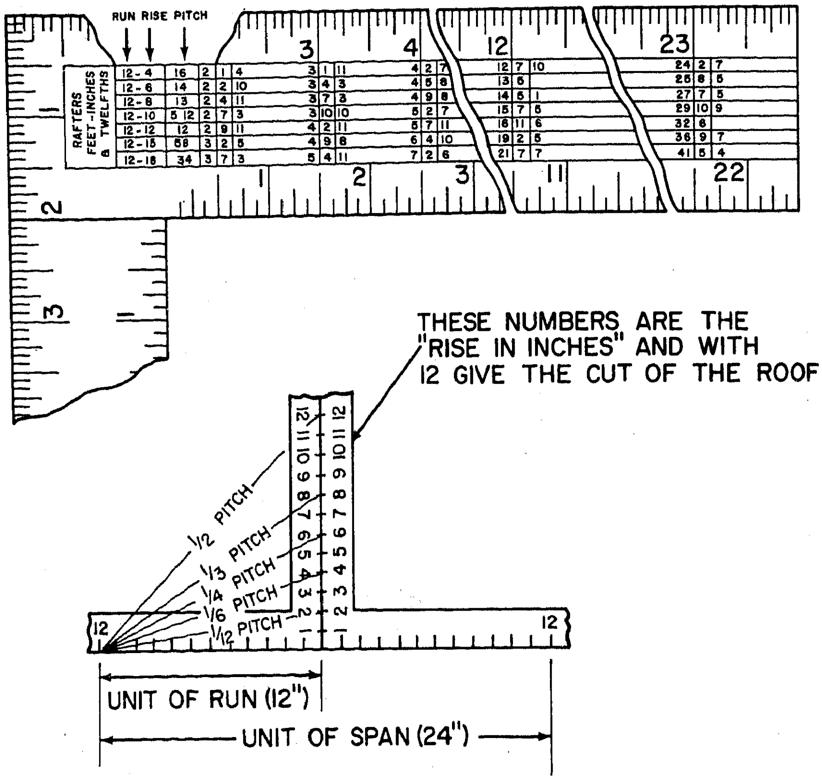


Figure 60. Rafter table method (type 2).

column of figures, in fractions, represents the various pitches.

(*a*) These three columns of figures show that a rafter with a run of 12 and a rise of 4 has one-sixth pitch, 12 and 6 has one-fourth pitch, and 12 and 12 has one-half pitch. To use this scale for a roof with one-sixth pitch (or the rise of one-sixth the width of the building) and a run of 12 feet, find 1/6 in the table, follow the same line of figures to the right until directly beneath the figure 12, appears the numbers 12, 7, 10, which is the rafter length required and which represents 12 feet 7 inches, and 10/12 of an inch. They are written as follows: 12 feet, 7 10/12 inches. For a pitch of one-half (or a rise of one-half the width of the building) and a run of 12 feet, the rafter length is 16, 11, 6, or 16 feet, 11 6/12 inches.

(*b*) If the run is over 23 feet, the table is used as follows: using a run of 27 feet, find the length for a run of 23

feet, then find the length of 4 feet and add the two. The run for 23 feet with a pitch of one-fourth is 25 feet, $8\frac{5}{12}$ inches. For 4 feet, the run is 4 feet, $5\frac{8}{12}$ inches. The total run for 27 feet is 30 feet, $2\frac{1}{12}$ inches. When the run is in inches, the rafter table reads inches and twelfths instead of feet and inches. For example if the pitch is one-half and the run is 12 feet, 4 inches add the rafter length of a 12-foot run to that of a rafte length of 4-inch run, as follows: for a run of 12 fee and one-half pitch, the length is 16 feet, $11\frac{9}{12}$ inch For a run of 4 inches and one-half pitch, the leng 5, 7, 11. In this case the 5 is inches, the 7 is twe and the 11 is $\frac{11}{12}$ of $\frac{1}{12}$, which is nearly $\frac{1}{12}$. Ad the 7 to make it 8, making a total of $5\frac{8}{12}$ inches add the two lengths together. This sum is 17 feet inches. The lengths that are given in the table a line lengths; the overhang must be added. After length of the rafter has been found, the rafter i out as explained in (*a*) above.

(*c*) When the roof has an overhang (fig. 57), the rafter is usually cut square to save time. When the roof has no overhang, the rafter cut is plumb, but no notch is cut in the rafter for a seat. The level cut is made long enough to extend across the plate and the wall sheathing. This type of rafter saves material, although little protection is given to the side wall.

49. Erection of Rafters

a. Rafters will seldom be put up singly; they are usually assembled into trusses, as shown in 1, 2, and 3, figure 61. Two rafters are connected at the top by using a collar tie well nailed into both rafters. Before any ties or chords are nailed, the rafters should be spread at the lower end to correspond to the width of the building. This may be accomplished by a template, or by measuring the distance between the seat cuts with a tape. A 1- by 6-inch or 2- by 4-inch chord is nailed across the rafters at the seat cut to tie them together. This chord forms a truss with the two rafters. A hanger or vertical member (4, fig. 61) of 1 by 6 is nailed to the rafter joint and this extends to the chord at midpoint, thus tying the rafter to the chord. If no additional bracing is required, the truss is ready to be set in place on the plates. If additional bracing is required, a knee brace is nailed to the chord. The knee brace forms an angle of 45° with the wall stud. To avoid hindrance in erection, the knee brace may be omitted until the rafter truss is set in place.

b. Rafter framing constructed without the use of ridgeboards may be rapidly completed by use of a truss assembly jig or template. The template is laid out (5 and 6, fig. 61) to form a pattern conforming to the exact exterior dimensions of the truss. Templates or jigs must be constructed accurately to assure proper dimensions of the rafter truss. Lay out a template in the following manner (6, fig. 61).

(1) Measure and mark a straight line on a selected surface, the exact length of the joists which will form the chord of the truss. This is the baseline A.

(2) From the center of the baseline and at right angles to it, lay out a line the length required to form the leg of a right triangle the base of which is half the length of the baseline A and the hypotenuse B which is the length of the rafter measured as indicated. This is the center line C.

(3) Nail 2- by 4- by 8-inch blocks flush with the ends of baseline A and centerline C as shown. Mark centerline on center jig blocks.

(4) Start assembly by setting a rafter in the jig with plate cut fitted over jig block at one end of baseline. Peak is flush with centerline on peak jig block. Nail a holding block outside rafter at point D.

(5) Assemble trusses in the following order: lay one 2- by 4-inch joist or chord in place across base blocks. Lay two 2- by 4-inch rafters in place over joist. Center one end of a 1- by 6-inch hanger under rafter peak. Center rafters against peak block. Nail through rafters into hanger with six 8-penny nails. Line up one end of chord. Nail through rafter with 16-penny nails. Line up other end of chord. Nail as above. Center bottom of hangers on top of chord and nail with 8-penny nails.

c. After the rafters have been assembled into trusses, they must be placed on the building. The first set of rafters may be assembled in the end section of the building or at the center as indicated in figure 62. The rafter trusses are raised by hand into position and nailed into place with 16- or 2-penny nails. These trusses are temporarily braced to the end section of the building, until the sheathing is applied. Temporary workbenches may be built for the workers to stand on while erecting these trusses, this will save time. The knee braces are not used on every rafter truss unless required. There are several methods for the actual installation. The following procedures may be used in the actual installation of trusses:

(1) Mark proper positions of all truss assemblies on top plate.

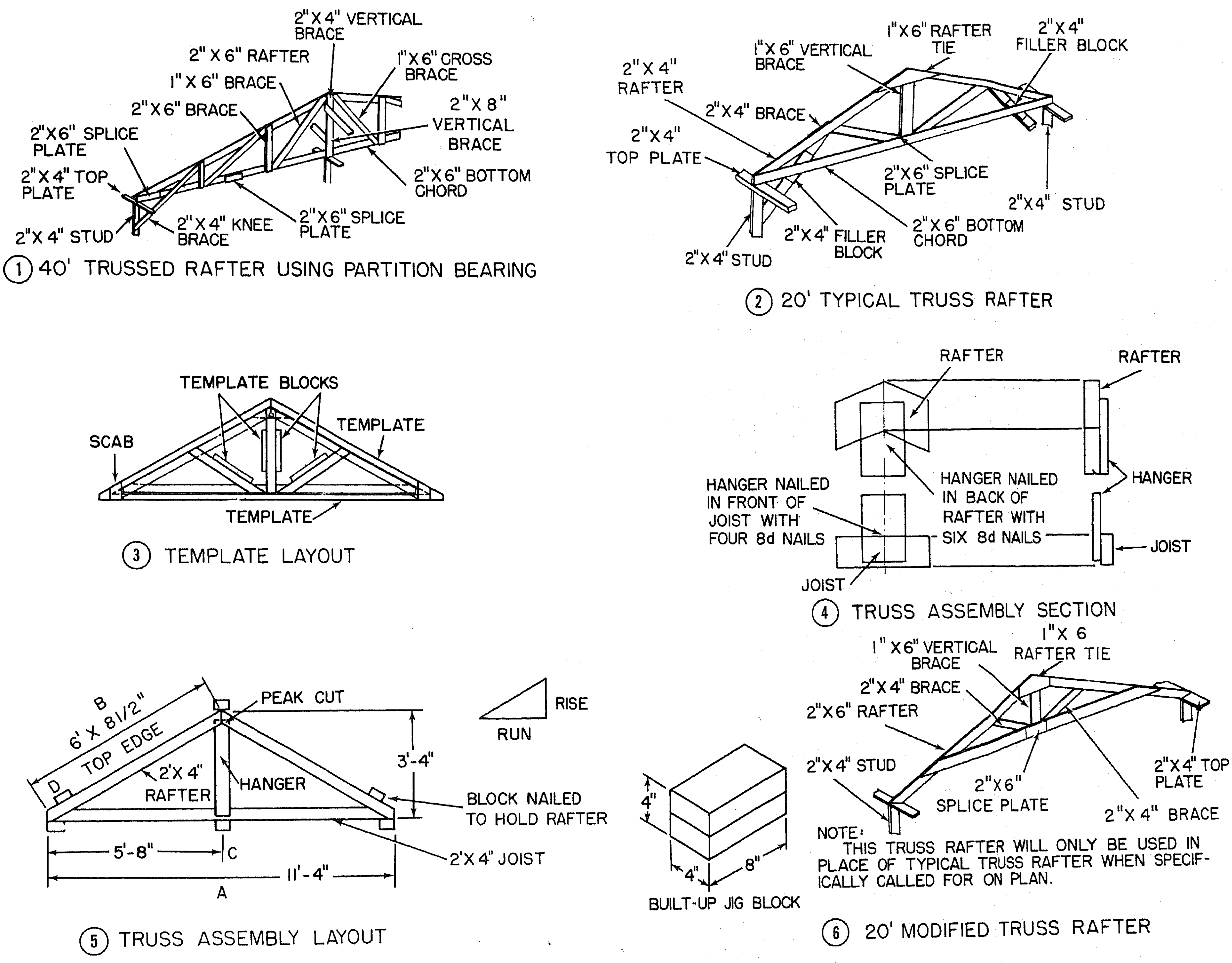


Figure 61. Rafter trusses.

The marks show the exact position of a given face of all rafters (south or north, etc.).

(2) Rest one end of a truss assembly, peak down, on an appropriate mark on top plate on one side of structure (1, fig. 62).

(3) Rest other end of truss on opposing mark on to[p] other side of structure (2, fig. 62).

(4) Rotate assembly into position by means of a po[le] (3, fig. 62).

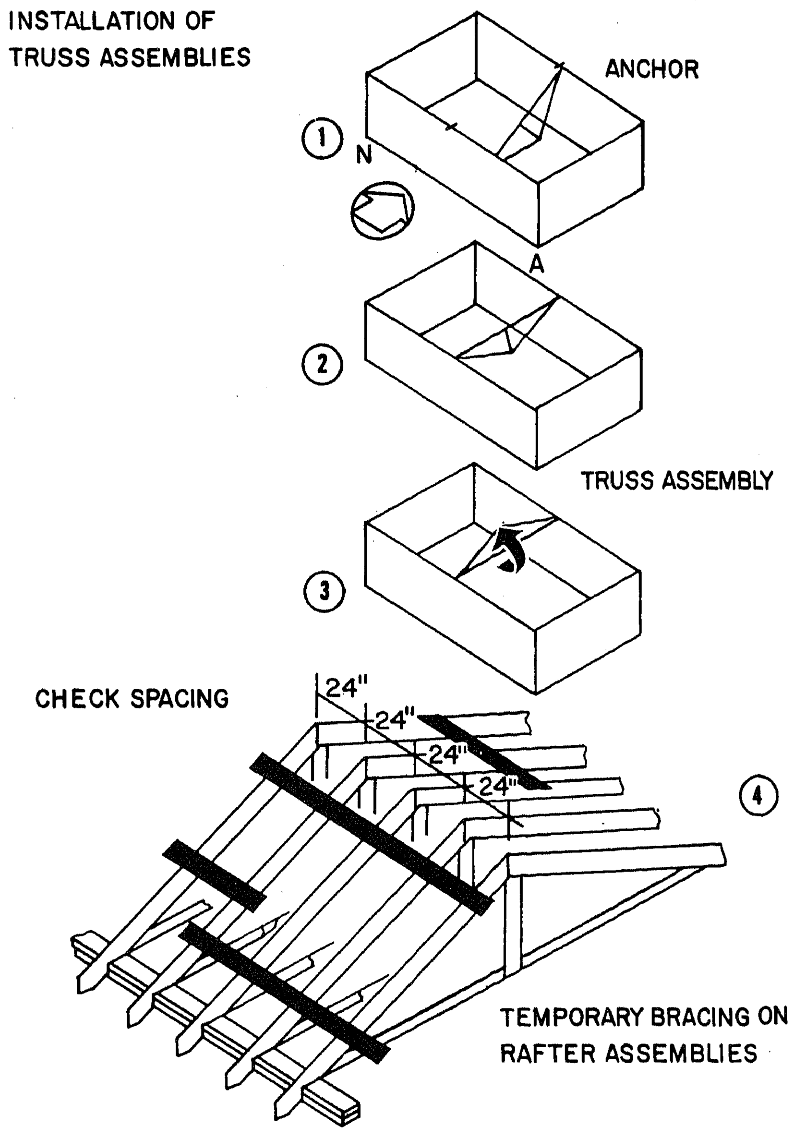


Figure 62. Erection of rafter trusses.

(5) Line up rafter faces flush against marks and secure.

(6) Raise, aline, and nail three assemblies into position. Nail temporary 1- by 6-braces across these three assemblies (4, fig. 62) and other assemblies as they are brought into position. Check rafter spacing at peaks as braces are nailed on.

(7) Braces may be used as a platform when raising those trusses for which there is too little room to permit rotation.

50. Bracing of Rafters

a. General. In small roofs which cover only narrow buildings and in which the length of the rafters is short, there is no need for interior support or bracing. In long spans, the roof would sag in the middle if it were not strengthened in some way. To support long rafters, braces or other types of supports must be installed.

b. Types.

(1) *Collar beams.* A collar beam or tie is a piece of stock (usually 1 by 4, 1 by 6, or 1 by 8) fastened to a pair of rafters in a horizontal position at some desired location between the plate and the ridge of the roof. This beam tends to keep the building from spreading. The lower the

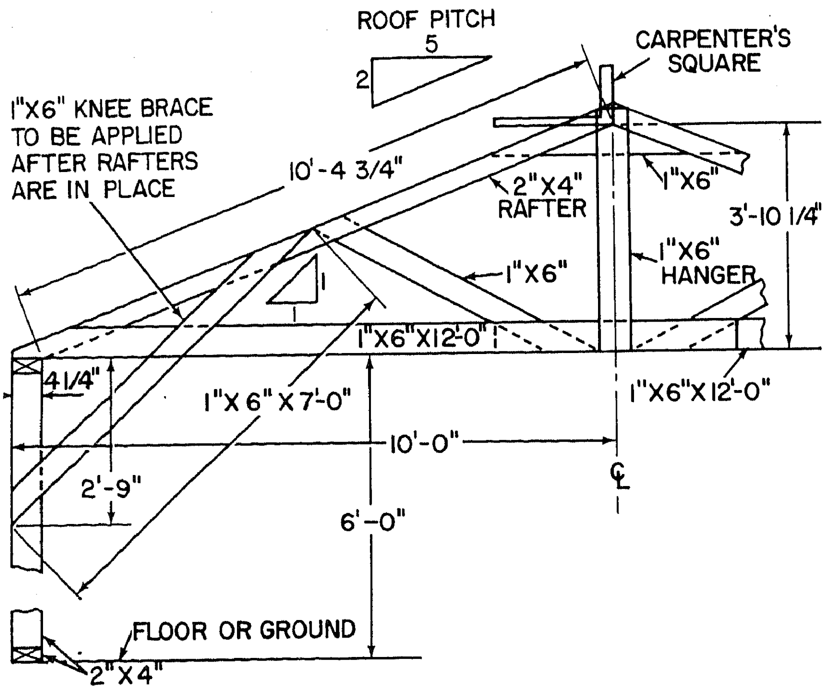


Figure 63. Rafter construction detail.

collar beam or chord, the better it fulfills its purpose. This type of bracing is used on small roofs where no ceiling joists are used and the building is not wide enough to require a truss.

(2) *Truss.* In wide buildings, where the joists or chords must be spliced and there is not support underneath, the rafter and joists support one another by means of the method shown in figure 63.

51. Timber Trusses

a. Definition. A truss is a framed or jointed structure composed of straight members connected only at their intersections in such a way that if the loads are applied at these intersections the stress in each member is in the direction of its length.

b. Types. The web members of a truss divide the truss into a number of triangles. It is possible to arrange innumerable types of trusses, but certain types have proved to be more satisfactory than others, and each of these types has its special uses. The various types of trusses used in building construction are illustrated by line diagrams in figure 64. The members indicated by heavy lines normally carry tensile stresses for vertical loads. Sometimes the top chords of these trusses are slightly sloping in one or two directions for roof drainage, but this does not change the type of truss. The necessary number of subdivisions or panels depends upon the length of the span and the type of construction.

c. Terms Used in Connection with Trusses.

(1) *Bottom chord* is a member which forms the lower boundary of the truss.

(2) *Top chord* is a member which forms the upper boundary of the truss.

(3) *Chord member* is a member which forms part of either the top or bottom chord.

(4) *Member* is the component which lies between any adjacent joints of a truss; it can be of one or more pieces of structural material.

(5) *Web member* is a member which lies between the top and bottom chords.

(6) *Joint* is any point in a truss where two or more members meet and is sometimes called a "panel point".

(7) *Panel length* is the distance between any two consecutive joint centers in either the top or bottom chords.

(8) *Pitch* is the ratio of the height of truss to the span length.

(9) *Height of truss* is the vertical distance at midspan from

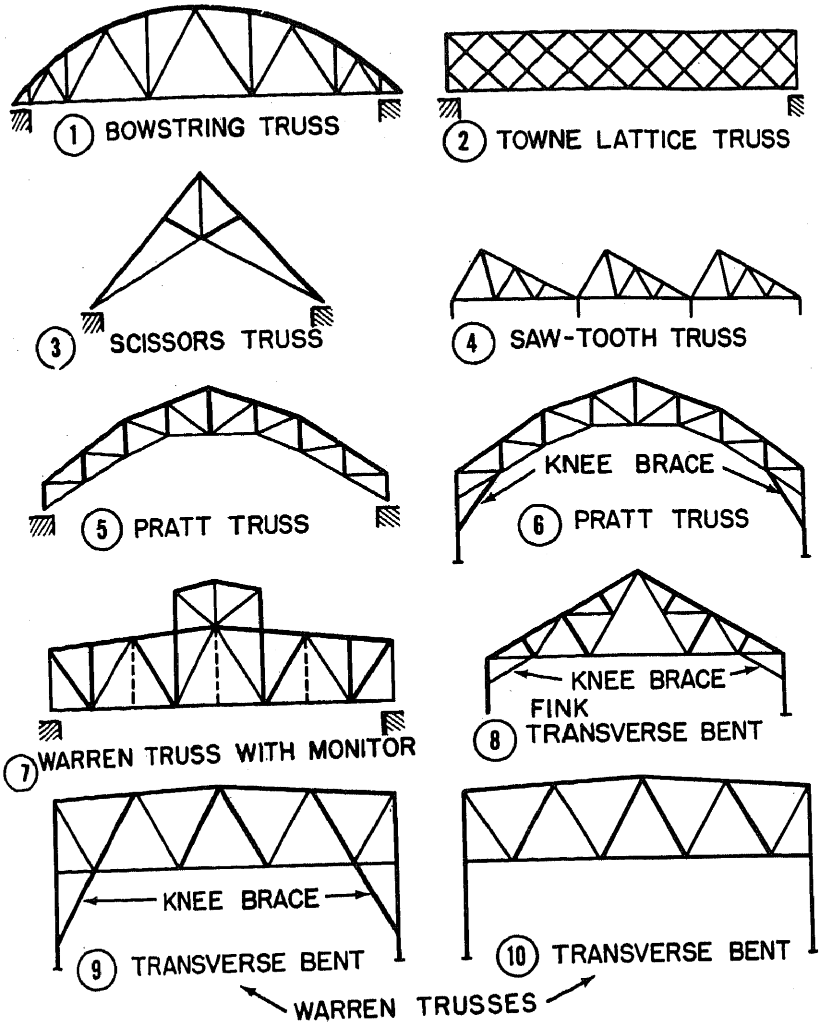


Figure 64. Types of trusses.

the joint center at the ridge of a pitched truss, or from the centerline of the top chord of a flat truss to the centerline of the bottom chord.

(10) *Span length* is the horizontal distance between the joint centers of the two joints located at the extreme ends of the truss.

d. Use. Timber trusses are used for large spans to provide wide unobstructed floor space for such large buildings as shops and hangers. The Howe and Fink trusses (fig. 64) are the ones most commonly used. Sometimes small buildings are trussed to save

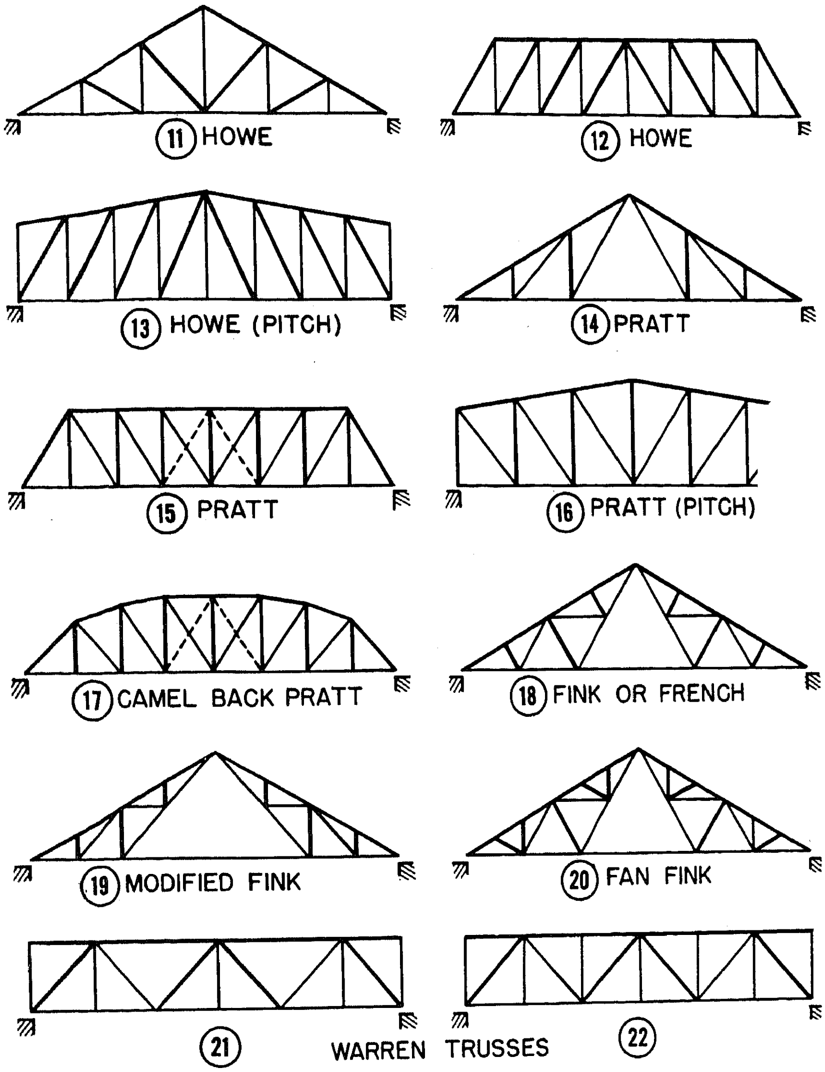


Figure 64—Continued.

material; these small trusses act as rafters and give the roof rigidity.

e. Support. Trusses are supported by bearing walls, posts, or other trusses. When it is desired to brace a truss to a wall or post, knee braces are used as shown in figure 65. These braces tend to make a truss of the entire building by tying the wall to the roof.

f. Layout. In laying out a truss (fig. 66), the first task is to get the material to a level spot of ground where workbenches will be approximately level. Obtain from the blueprints the necessary

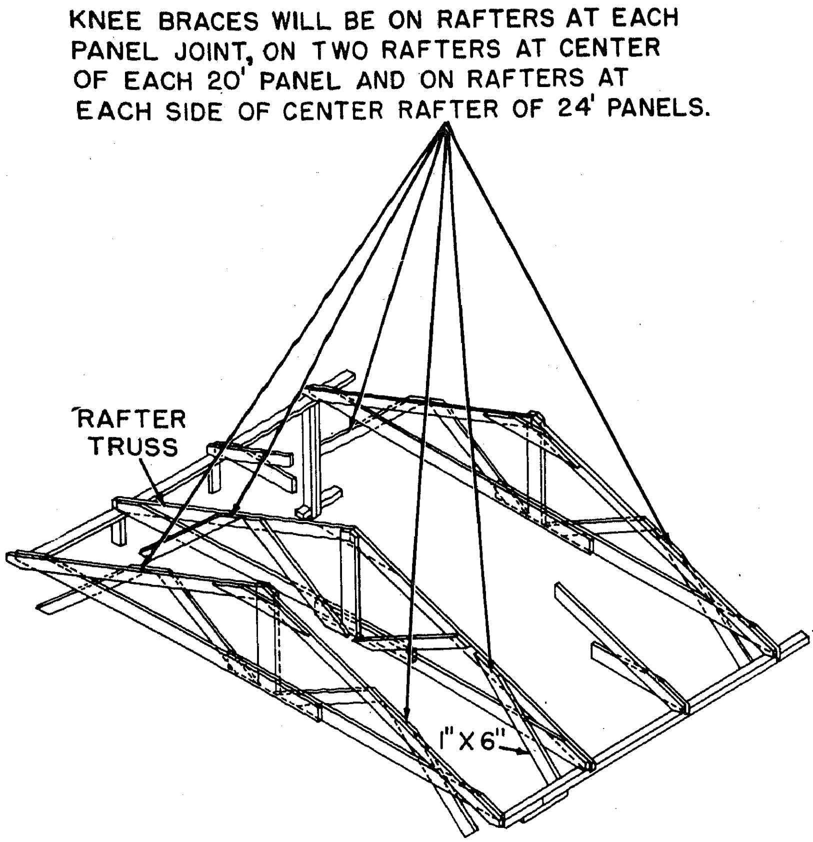


Figure 65. Truss and knee braces.

measurement of all pieces that are to be used in the truss. Lay out the length on the different sizes of timber and cut them. Care must be taken that the lengths are cut accurately. After all the lengths of different sizes of material for a truss have been cut, lay the pieces in their correct position to form a truss and nail them together temporarily. After the truss is assembled in this manner, lay out the location of all holes to be bored, then recheck the measurements to be sure that they are correct; after this is done, bore the holes to the size called for on the print. They may be bored with a brace and bit, or with the woodborer which accompanies the air compressor. They should be bored perpendicular to the face of the timber. After the holes have been bored, the truss is dismantled and the nails withdrawn.

g. Assembly. The assembling of a truss after it has been cut and bored is simple. In most cases, timber connectors are used where the different members of the truss join. The truss is again

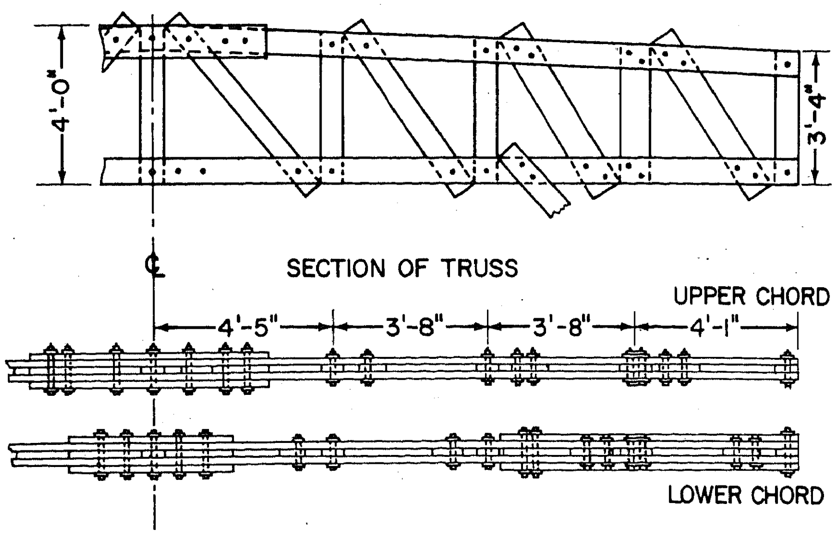


Figure 66. Section of truss.

assembled as it was for boring holes, with the timber connectors in place. The bolts are then placed in the holes and tightened, a washer being placed at the head and nut ends of each bolt. Straight and sound timber should be used in trusses to avoid weak places.

h. Purlins. Purlins are used in roof construction where corrugated sheet metal is used, or to support the sheathing when roofs are framed with trusses. In small roofs, short purlins are inserted between the rafters and nailed through the rafters as shown in figure 32. They are used to support the sheet metal. Where heavy trusses are used, the purlins are continuous members which rest on the trusses and support the sheathing. This type of purlin is used only in large buildings. In small buildings, such as barracks, mess halls, and small warehouses, 2 by 4's are used for purlins, with the narrow side up.

Section V. OPENINGS

52. Floor Openings

a. General. Floor openings for stairwells, ventilators, chimneys, etc., are framed by a combination of headers and trimmers. Headers run at right angles to the direction of the joists and are doubled. Trimmers run parallel to the joists and are actually doubled joists. The joists are framed to the headers where the headers form the opening frame at right angles to the joists. These shorter joists, framed to the headers are called tail beams, tail joists, or header joists. The number of headers and trimmers re-

quired at any opening depends upon the shape of the opening, whether it is a simple rectangle or contains additional angles; upon the direction in which the opening runs in relation to the direction in which the joists run; and upon the position of the opening in relation to partitions or walls. Figure 67 illustrates examples of openings, one of which runs at right angles to the run of the joists and therefore requires one header and two trimmers, while the other runs parallel to the joist and requires two headers and one trimmer. The openings shown in figure 68 are constructed with corner angles supported in different ways. The cantilever method

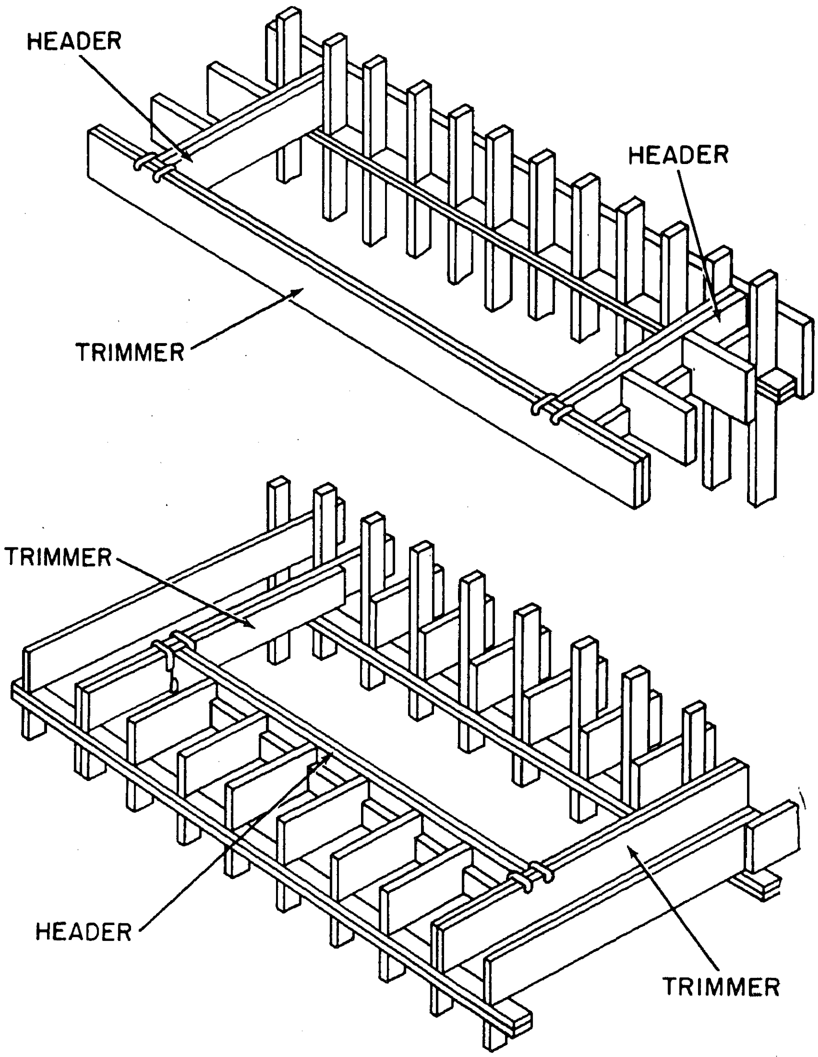


Figure 67. Floor openings paralleled with and at right angles to joists.

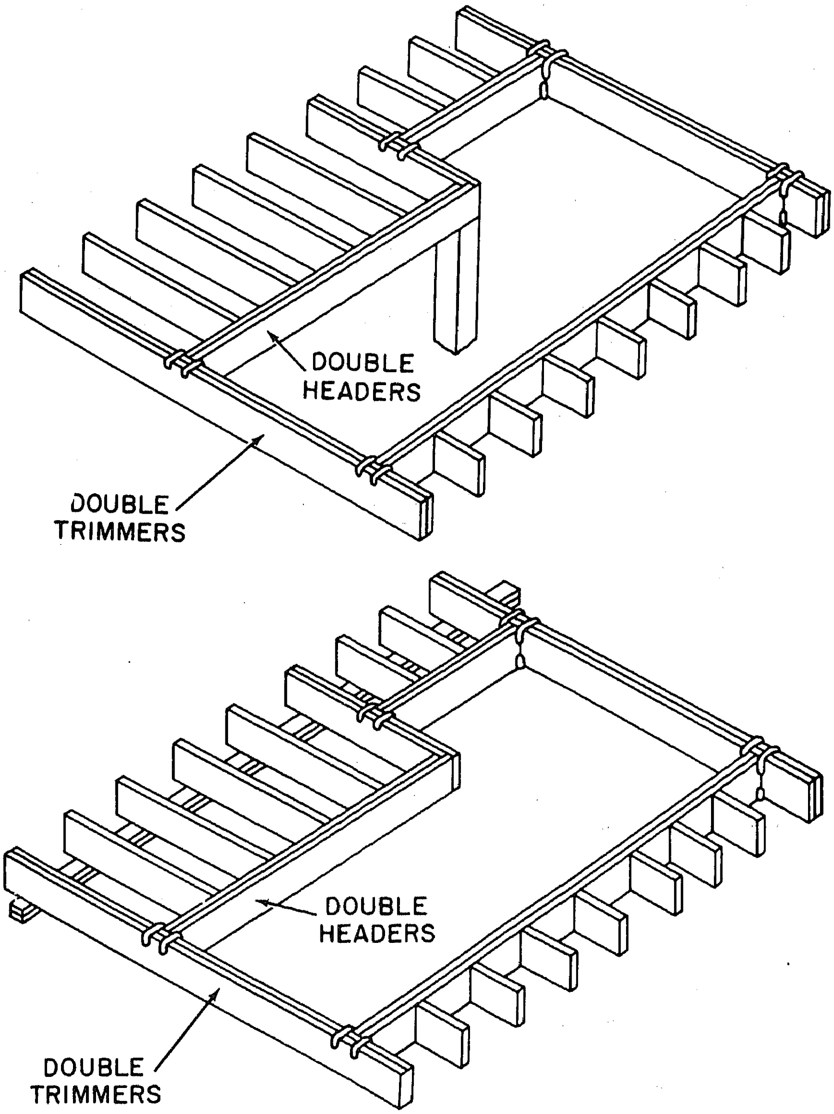


Figure 68. Headers and trimmers as used in two different floor openings.

requires that the angle be fairly close to a supporting partition with joists from an adjacent span that run to the header.

b. Construction. To frame openings of the type shown in figure 69, first install joists *A* and *C*, then cut four pieces of timber that are the same size as the joists with their length corresponding to the distance between the joists *A* and *C* at the outside wall. Nail two of these pieces between the joists at the desired distances from the ends of the joists; these pieces are shown as headers Nos. 1 and

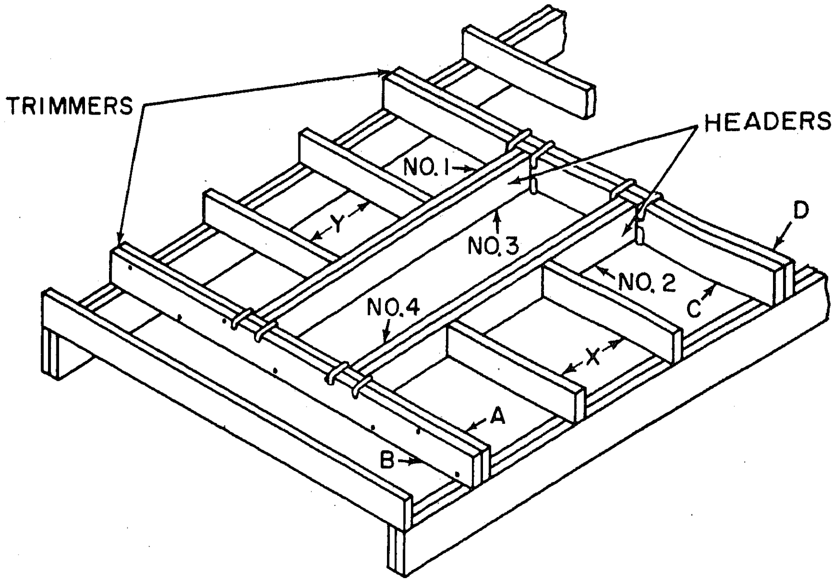


Figure 69. Floor opening construction.

... 69. Install short joists *X* and *Y*, as shown. The nails .6- or 20-penny nails. By omitting headers Nos. 3 and 4 *B* and *D*, the short joists *X* and *Y* can be nailed in place ıe header and the headers can be nailed through the joists ınto its end. After the header and short joists have been nailed, headers Nos. 3 and 4 are nailed beside Nos. 1 and 2. ınen joist *B* is placed beside joists *A* and joist *D* beside *C*, and all are nailed securely.

53. Roof Openings

a. General. Major roof openings are those which require interruption of the normal run of rafters or other roof framing. Such openings may be required for ventilator, chimney, or trap door passage or for skylight or dormer windows.

b. Construction. Roof openings, like floor openings, are framed by headers and trimmers (fig. 70). Double headers are used at right angles to the rafters which are set into the headers in the same manner as joists in floor opening construction. Just as trimmers are double joists in floor construction, they are actually double rafter construction in roof openings. Nailing strips may be added if required.

54. Doors

a. General. Door and window openings in exterior walls generally require double headers (fig. 71). Regular studs normally

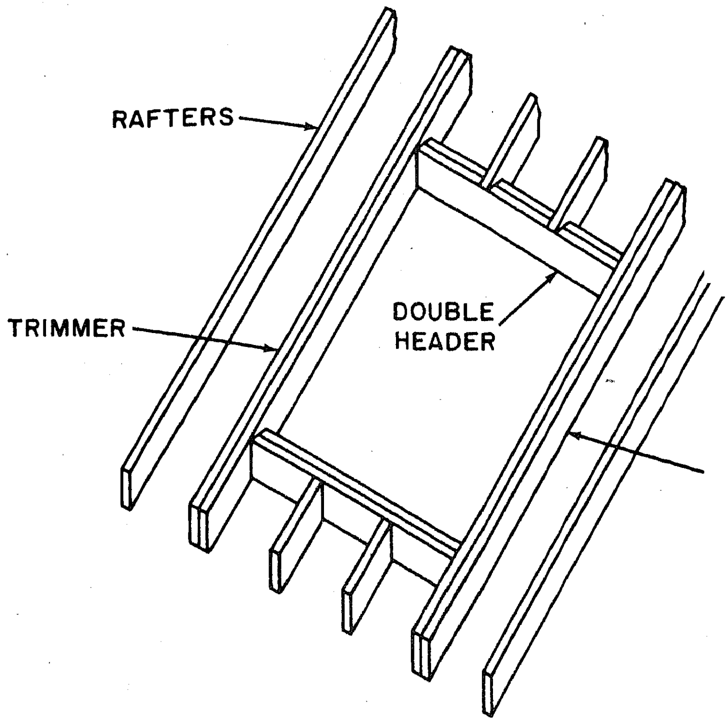


Figure 70. Roof opening construction.

are placed 16 inches on center and extra studs are used at the sides of all such openings. Openings should allow ½ inch between the back at jamb and framing member for the plumbing and leveling of jambs.

b. Door Frames.

(1) Before the exterior covering is placed on the outside walls, the door openings are prepared for the frames. To prepare the openings, square off any uneven pieces of sheathing and wrap heavy building paper around the sides and top. Since the sill must be worked into a portion of the rough flooring, no paper is put on the floor. Position the paper from a point even with the inside portion of the stud to a point about 6 inches on the sheathed walls and tack it down with small nails.

(2) Outside door frames are constructed in several ways. In most hasty construction, the frames will be as shown in figure 71. This type requires no frame, as the studs on each side of the opening act as a frame. The outside finish is applied to the wall before the door is hung. The casing is then nailed to the sides of the opening, set back the

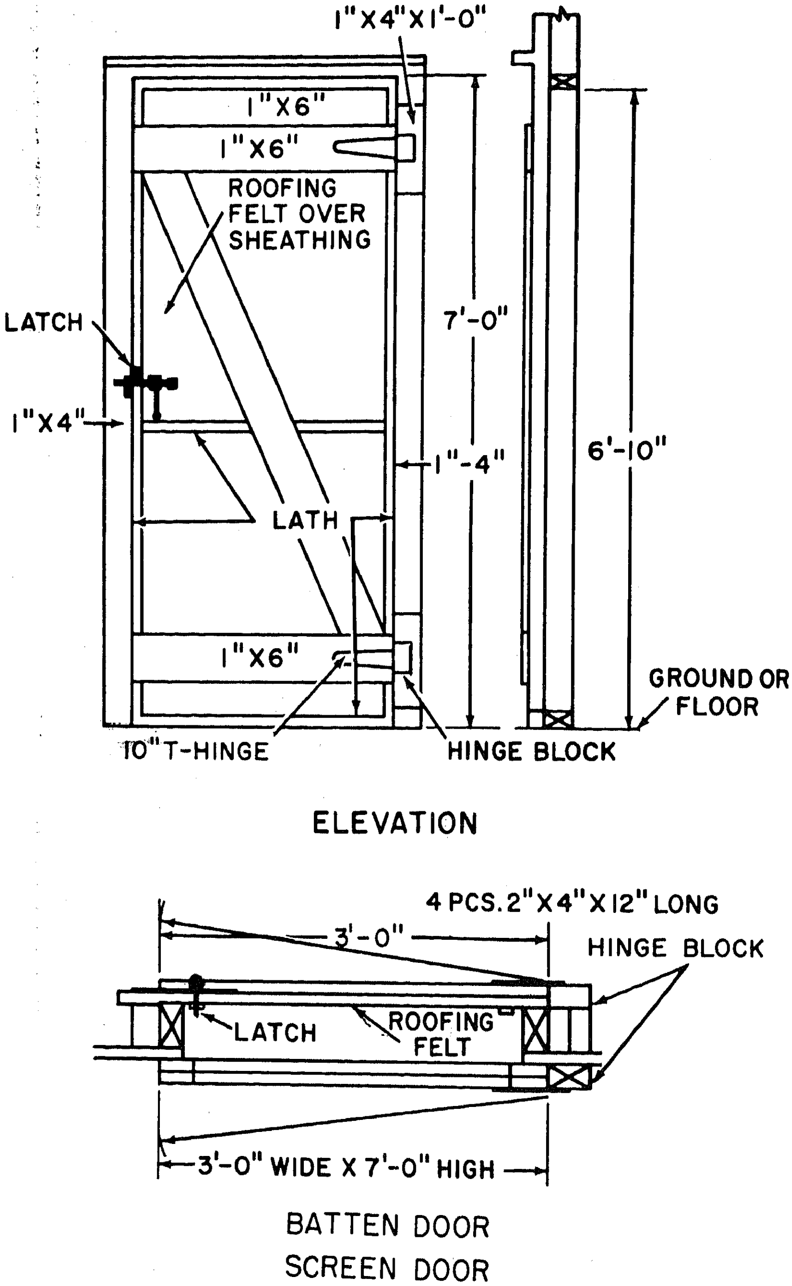


Figure 71. Single outside door.

width of the stud. A $\frac{3}{4}$- by $\frac{3}{4}$-inch piece is nailed over the door to act as a support for the drip cap and is also set back the width of the stud. Hinge blocks are nailed to the casing where the hinges are to be placed. The door frame is now complete and ready for the door to be hung.

(3) Inside door frames, like outside frames are constructed in several ways. In most hasty construction, the type shown in figure 72 will be used. The interior type is constructed like the outside type except that no casing is used on inside door frames. Hinge blocks are nailed to the inside wall finish, where the hinges are to be placed, to provide a nailing surface for the hinge flush with the door. Figure 72 shows the elevation of a single inside door. Both the outside and inside door frames may be modified to suit a climatic condition.

c. Door Jambs. Door jambs (fig. 73) are the linings of the framing of door openings. Casings and stops are nailed to the door jambs and the door is hung from them. Inside jambs are made of $\frac{3}{4}$-inch stock and outside jambs of $1\frac{3}{8}$-inch stock. The width of the stock will vary in accordance with the thickness of the wall. Inside jambs are built up with $\frac{3}{8}$- by $1\frac{3}{8}$-inch stops nailed to the jamb, while outside jambs are usually rabbeted out to receive the door. Jambs are made and set in the following manner:

(1) Regardless of how carefully rough openings are made, be sure to plumb the jambs and level the heads, when jambs are set.

(2) Rough openings are usually made $2\frac{1}{2}$ inches larger each way than the size of the door to be hung. For example, a 2-foot 8-inch by 6-foot 8-inch door would need a rough opening of 2 feet $10\frac{1}{2}$ inches by 6 feet $10\frac{1}{2}$ inches. This extra space allows for the jambs, the wedging, and the clearance space for the door to swing.

(3) Level the floor across the opening to determine any variation in floor heights at the point where the jambs rest on the floor.

(4) Now cut the head jamb with both ends square, having allowed width of the door plus the depth of both dadoes and a full $\frac{3}{16}$ inch for door clearance.

(5) From the lower edge of the dado, measure a distance equal to the height of the door plus the clearance wanted under it. Mark and cut square.

(6) On the opposite jamb do the same, only make additions or subtractions for the variation in the floor, if any.

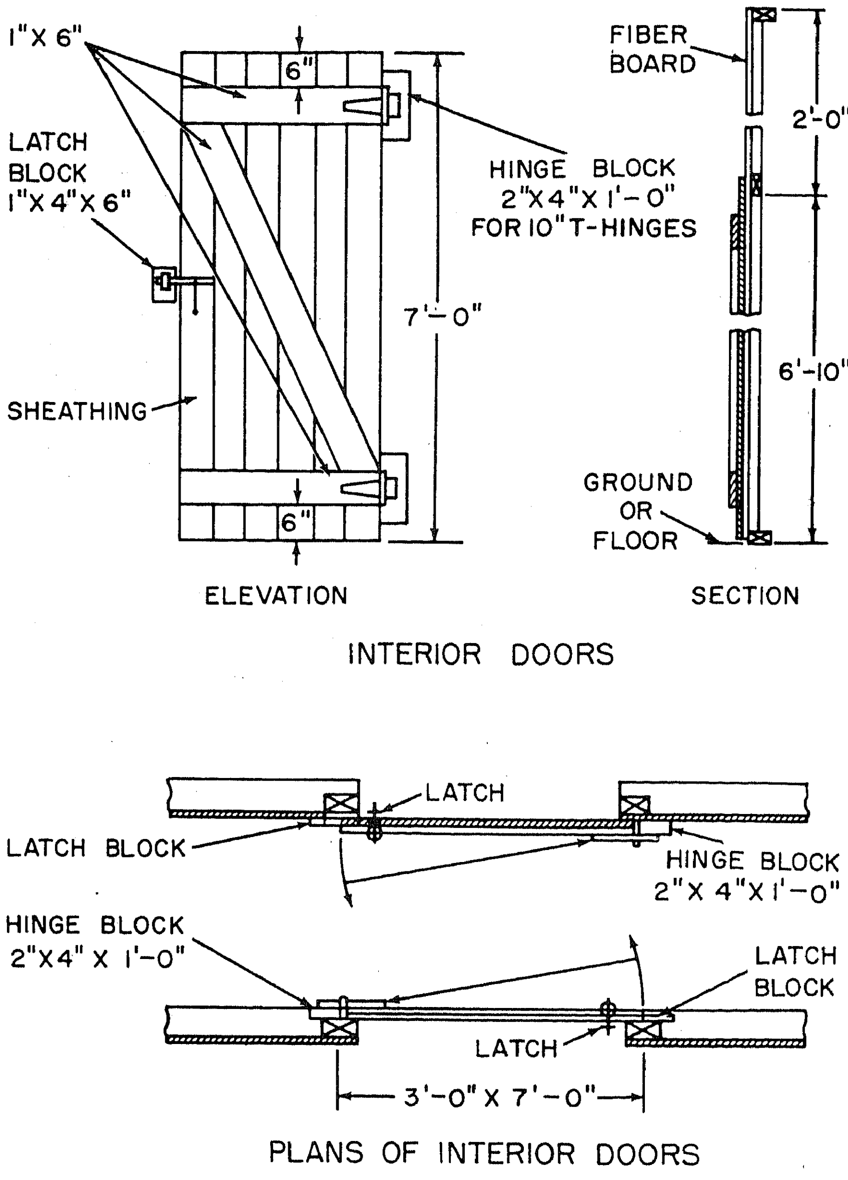


Figure 72. Single inside door.

(7) Now nail the jambs and jamb heads together with 8-penny common nails through the dado into the head jamb.

(8) Set the jambs into the opening and place small blocks under each jamb on the subfloor just as thick as the finish floor will be. This is to allow the finish floor to go under.

(9) Plumb the jambs and level the jamb head.

(10) Wedge the sides with shingles between the jambs and the studs, to aline, and then nail securely in place.

(11) Take care not to wedge the jamb unevenly.

(12) Use a straightedge 5 or 6 feet long inside the ja help prevent uneven wedging.

(13) Check jambs and head carefully, because jambs pla of plumb will have a tendency to swing the door (shut, depending on the direction in which the jaml of plumb.

d. Door Trim. Door trim material is nailed onto the j provide a finish between the jambs and the plastered wa frequently called "casing" (fig. 73). Sizes vary from ½ inches in thickness, and from 2½ to 6 inches in width. Mo has a concave back, to fit over uneven plaster. In mitere care must be taken to make all joints clean, square, neat fitted. (If the trim is to be mitered at the top corners, a miter square, hammer nail set, and block plane will b Door openings are cased up in the following manner:

(1) Leave a margin of ¼-inch from the edge of the the casing all around.

(2) Cut one of the side casings square and even at the with the bottom of the jamb.

(3) Cut the top or mitered end next, allowing ¼-inch extr length for the margin at the top.

(4) Nail the casing onto the jamb and even with the ¼-inch margin line, starting at the top and working toward the bottom.

(5) Use 4-penny finish nails along the jamb side and 6-penny or 8-penny case nails along the outer edge of the casings.

(6) The nails along the outer edge will need to be long enough to go through the casing and plaster and into the studs.

(7) Set all nailheads about ⅛ inch below the surface of the wood with a nail set.

(8) Now apply the casing for the other side and then the head casing.

55. Windows

a. General. Windows are generally classified as sliding, double hung, and casement (fig. 74). All windows, whatever the type, consist essentially of two parts, the frame and the sash. The frame is made up of four basic parts: the head, the jambs (two), and the sill. Good construction around the window frame is essential to good building. Where openings are provided, studding must be cut

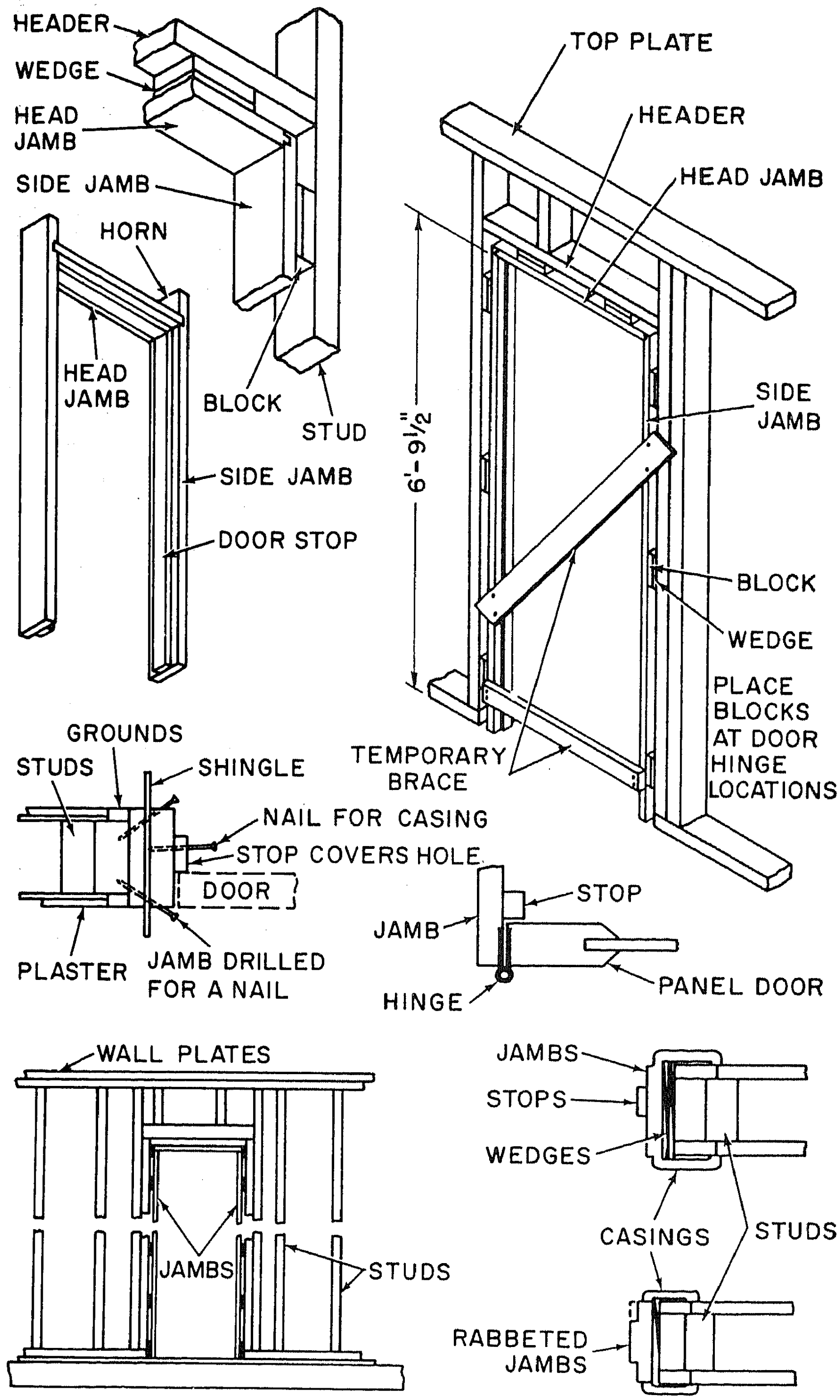
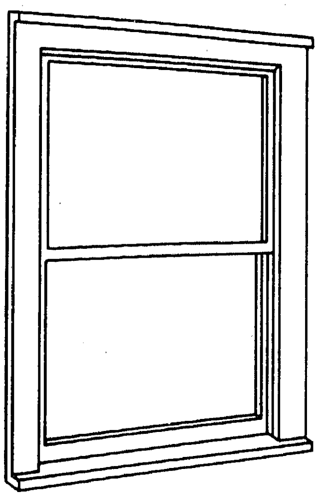


Figure 73. Door jamb and door trim.

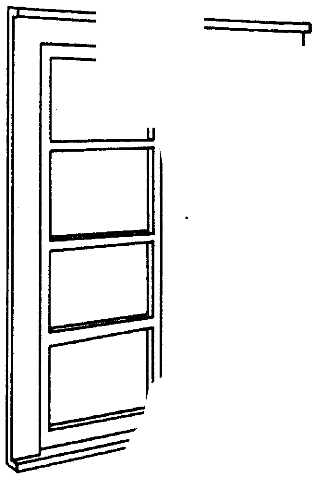
away and its equivalent strength replaced by doubling th each side of the opening to form trimmers and insertin at the top. If the opening is wide, the header should and trussed. At the bottom of the op rough sill is inserted.

b. Window Frames. These are sashes are fitted and hung. They the wall framing and are intended rough window opening is made at (width and height) than the win sash to be used is, for instance, inches, add 10 inches to the widt width of 34 inches for the rough o



1

DOUBLE HUNG



glasses (26 inches each) and an additional 10 inches for the total height of the rough opening, 62 inches. These allowances are standard and provide for weights, springs, balances, room for plumbing and squaring, and for regular adjustments.

c. Sliding or Double-Hung Window. The double-hung window (fig. 75) is made up of two parts: an upper and a lower sash, which slide vertically past one another. This window has some advantages and disadvantages. Screens can be located on the outside of a double-hung window without interfering with its operation, and ventilators and window air conditioners can be placed with the window mostly closed. However, for full ventilation of a room, only one-half of the area of the window can be utilized, and any current of air passing across its face is to some extent lost to the room. Double-hung windows are somewhat more involved in their frame construction and operation than the casement.

(1) The box frame (fig. 75) consists of a top piece or yoke; two side pieces or jambs called pulley stiles, and the sill. The yoke and pulley stiles are dadoed into the inner and outer pieces (rough casing), forming an open box with the opening toward the studs and headers. The rough casing provides nailing surface to the studs and headers forming the plaster stop. The outside rough casing is also a blind stop for sheathing which should fit snugly against it, with building paper lapping the joint.

(2) The 2-inch space between the framing studs and the pulley stile forms the box for counterweights which balance the window sash. The weight box is divided by a thin strip known as the pendulum, which separates the weights for the two sash units. In the stiles near the sill is an opening for easy access to the weights. This opening has a removable strip which is part of the stile and channel for the lower sash (fig. 75).

(3) Yoke and stile faces are divided by a parting strip which is dadoed into them, but removable so that the upper sash can be taken out. The strip forms the center guide for the upper and lower sash, while the outer rough casing, projecting slightly beyond the stiles and yoke, forms the outer guide. The inner guide for the sash is formed by a strip or stop, usually with a molding form on the inner edge. This stop is removable to permit the removal of the lower sash.

(4) At the upper parts of the stiles, two pulleys on each side (one for each sash) are mortised flush with the stile faces for the weight cord or chain.

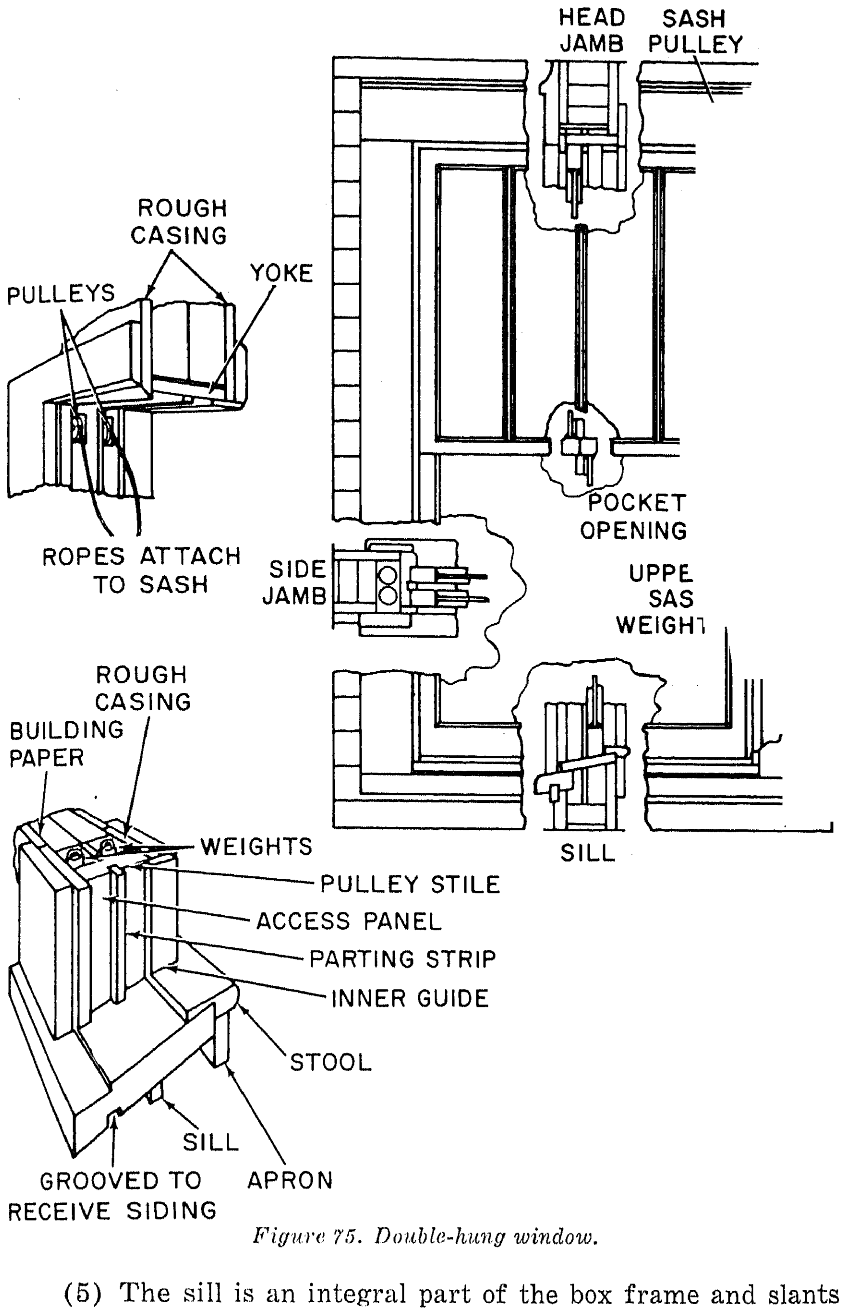


Figure 75. Double-hung window.

(5) The sill is an integral part of the box frame and slants downward and outward. It usually has one or two ¼-inch brakes, one occurring at the point where the lower sash rests on the sill, and another near the outer edge to form a seat for window screens or storm sash. These brakes prevent water, dripping on the sill, from being blown

under the sash. The underside of the sill, near its outer edge, is grooved to receive the edge of siding material to form a watertight seal.

(6) On the room side of the sill is another piece, the stool, which has a rabbet on its underside into which the sill fits. The stool edge projects from the sill, forming a horizontal stop for the lower sash. The stool is part of the interior trim of the window, made up of side and top casings and an apron under the stool. The framed finished side and top casings are on the weather face. A drip cap rests on top of the outside head casing and is covered with metal flashing to form a watertight juncture with the siding material.

d. Hinged or Casement Windows. There are basically two types of casement windows, the outswinging and the inswinging types, and these may be hinged at the sides, top, or bottom. The casement window which opens out—the way a casement should open for the most efficient water tightness when closed—requires the window screen to be located on the inside with some device cut into its ... nent; or the window screen must be ... operate the window. Inswinging case- ... windows are clear of screens, but they are ... make watertight, particularly against a ... ainstorm. This is why most casement windows swing out. Casements have the advantage of their entire area being opened to air currents, with the added advantage of catching a parallel breeze and slanting it into a room.

(1) Casement windows are considerably less complicated in their construction, being simple frames and sash. The frames are usually made of planks $1\frac{3}{4}$ inch thick with rabbets cut in them to receive the sash. Usually there's an additional rabbet for screens or storm sash. The frames are rabbeted $\frac{1}{2}$-inch deep and $1\frac{1}{2}$ or $1\frac{7}{8}$ inches wide for sash $1\frac{3}{8}$ or $1\frac{3}{4}$ inches thick. The additional rabbet is usually $1\frac{5}{16}$ or $1\frac{3}{16}$ inches wide, depending on whether the screen or storm sash is $\frac{7}{8}$ or $1\frac{1}{8}$ inch thick.

(2) Outswinging casement windows have the rabbet for the sash on the outer edges of the frame, the inner edge being rabbeted for the screen. Sill construction is very much like that for a double-hung window, with the stool much wider and forming a stop for the bottom rail. Casement-window frames are of a width to extend to the sheathing face on the weather side and to the plaster face on the room side (fig. 76).

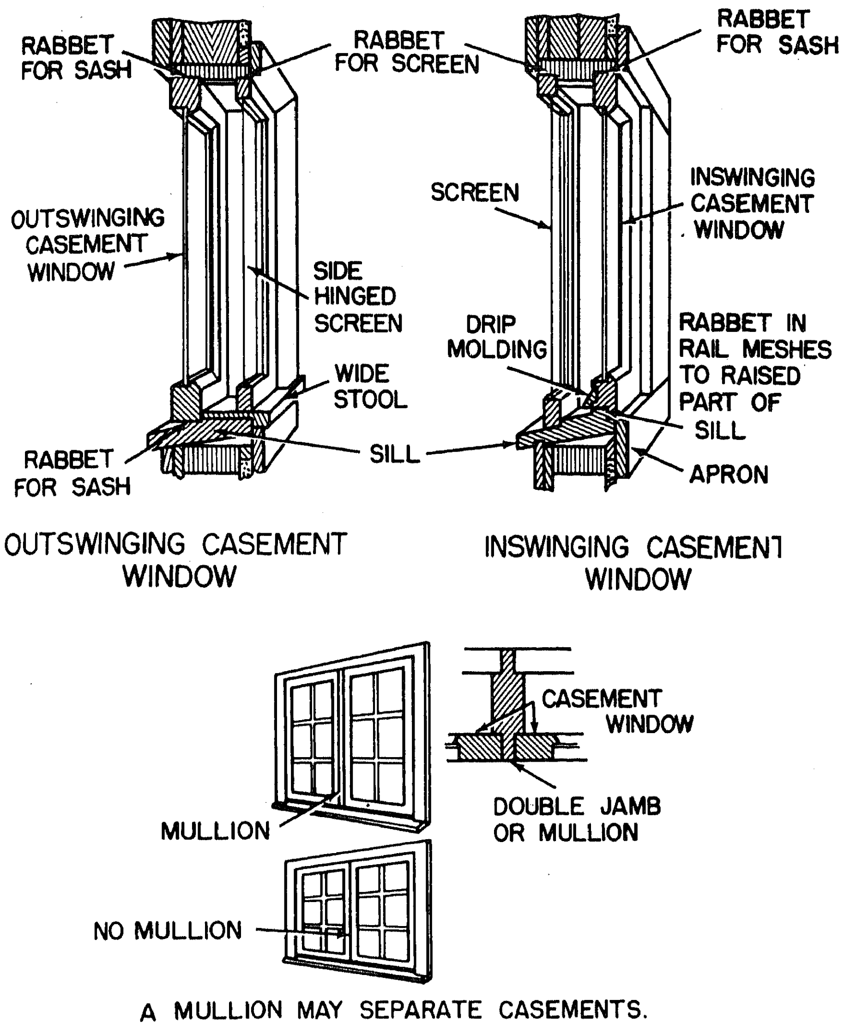


Figure 76. Casement windows.

(3) When there are two casement windows in a row in one frame, they may be separated by a vertical double jamb called a mullion, or the stiles may come together in pairs like a french door. The edges of the stiles may be a reverse rabbet; a beveled reverse rabbet with battens, one attached to each stile; or beveled astragals (T-shaped molding), one attached to each stile. The battens and astragals insure better weathertightness. The latter are more resistant to loosening through use. Two pairs of casement sash in one frame are hinged to a mullion in the center (fig. 76).

(4) Inswinging casement-window frames are like the outswinging type with the sash rabbet cut in the inner edge of the frame. The sill construction is slightly different, being of one piece (similar to that of a door sill) with a rabbet cut for a screen or storm sash toward the front edge, and the back raised where the sash rail seats. This surface is rabbeted at its back edge to form a stop for the rail which is also rabbeted to mesh.

(5) Sills in general have a usual slope of about 1 in 5 inches so that they shed water quickly. They are wider than the frames, extending usually to the plaster line and about 1½ inches beyond the sheathing. They also form a base for the outside finished casing.

(6) The bottom sash rail of an inswinging casement window is constructed differently than the outswinging type. The bottom edge is rabbeted to mesh with the rabbet on the sill, and a drip molding is set in the weather face to prevent rain from being blown under the sash.

e. Window Frames. In hasty construction, millwork window frames are seldom used. The window frames are mere openings left in the walls with the stops all nailed to the stud. The sash may be hinged to the inside or the outside of the wall or constructed so as to slide. The latter type of sash is most common in Army construction because it requires little time to install. Figure 77 shows the section and plan of a window and window frame of the type used in the field. After the outside walls have been finished, a 1 by 3 is nailed on top of the girt at the bottom of the window opening to form a sill. A 1 by 2 is nailed to the bottom of the plate and on the side studs and acts as a top for the window sash. One guide is nailed at the bottom of the opening flush with the bottom of the girt, and another is nailed to the plate with the top edge flush with the top of the plate. These guides are 1 by 3's, 8 feet long. Stops are nailed to the bottom girt and plate, between the next two studs, to hold the sash in position when open (fig. 77).

56. Other Wall Openings

a. Stovepipes. Stovepipes carried outside a building through a side wall eliminate the need for flashing and waterproofing around the pipe (fig. 78). The opening should be cut in an area selected to avoid cutting studs, braces, plates, and so on. Sheathing must be cut back in a radius 6 inches greater than that of the pipe. Safety thimbles or other insulation must be used on the inside and outside of the sheathing. Sheet metal insulation may be con-

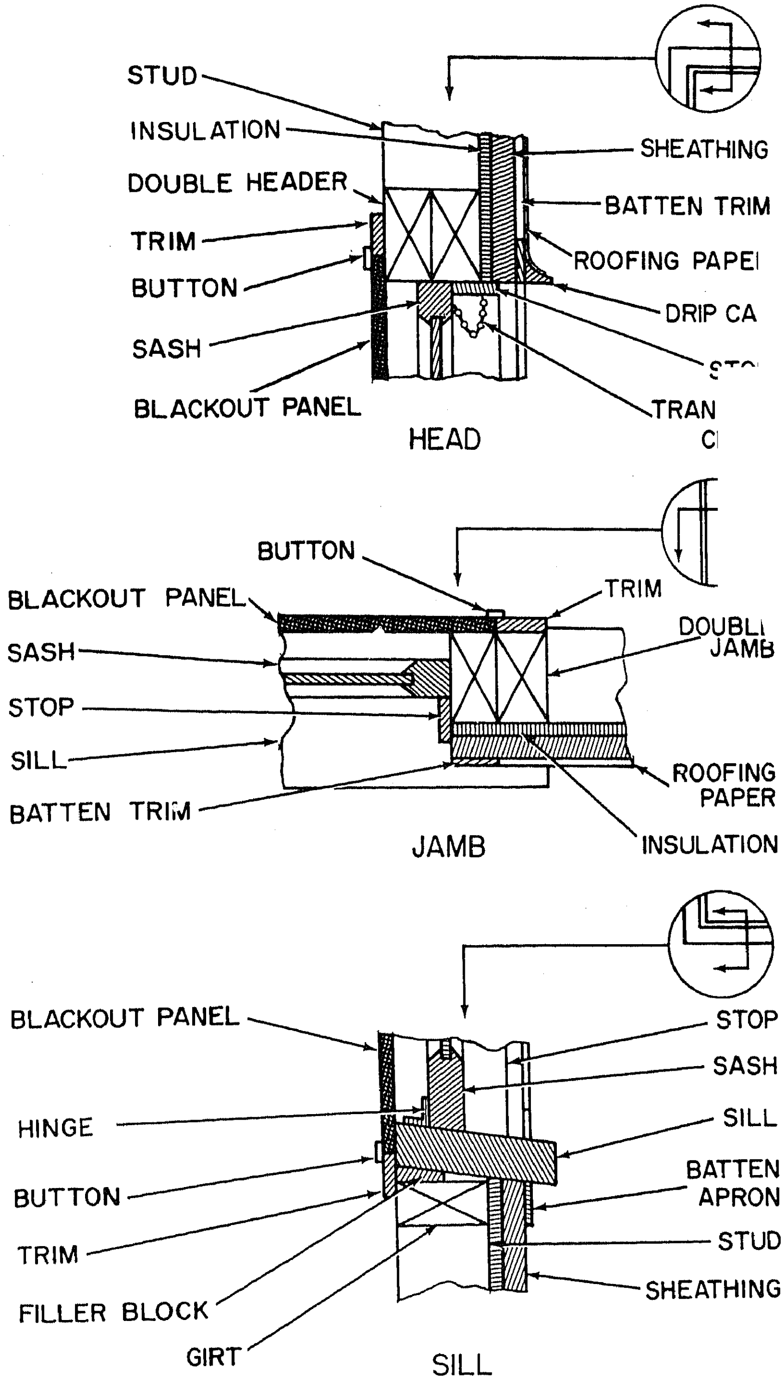


Figure 77. Detail of wall section with window frame and sash.

structed and used as a single insulator on the outside. In making openings, proceed as follows:

(1) Cut a hole through the sheet metal where the stovepipe is to penetrate.

(2) Mark a circle on the metal ½-inch larger in diameter than the pipe and then make another circle within this circle with a diameter 2 inches less than the diameter of the first.

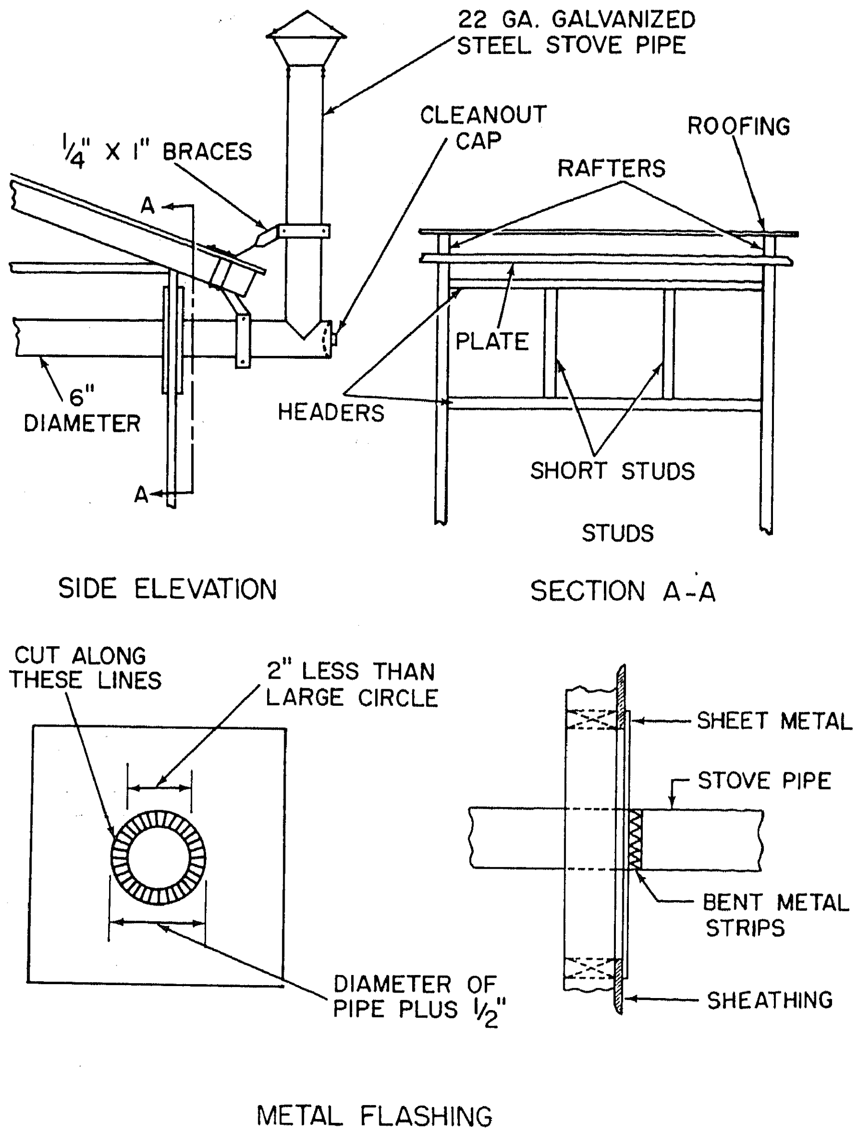


Figure 78. Preparation of wall opening for stovepipe.

(3) With a straightedge, draw lines through the center of the circle from the circumference. These marks should be from ½ to ¾ inch apart along the outer circumference.

(4) Cut out the center circle, then cut to the outside of the circle along the lines drawn. After the lines have been cut, bend the metal strips outward at a 45° angle and force the pipe through the hole to the desired position. Very little water will leak around this joint.

b. Ventilators. Adequate ventilation is necessary in preventing condensation in buildings. Condensation may occur in the walls, in the crawl space under the structure, in basements, on windows, and so on. Condensation is most likely to occur in structures during the first 6 to 8 months after a building is built, and in extreme cold weather when interior humidity is high. Proper ventilation under the roof allows moisture laden air to escape during the winter heating season and also allows the hot dry air of the summer season to escape. The upper areas of a structure are usually ventilated by the use of louvers or ventilators.

(1) *Types of ventilators* (fig. 79). Types of ventilators used are as follows:

(*a*) Roof louvers (1).

(*b*) Cornice ventilators (2).

(*c*) Gable louvers (3).

(*d*) Flat-roof ventilators (4).

(*e*) Crawl-space ventilation (5).

(*f*) Ridge ventilators (6).

(2) *Upper structure ventilation.* One of the most common methods of ventilating is by the use of wood or metal louver frames. There are many types, sizes, and shapes of louvers. Following are the points to consider when building or installing the various means of ventilation:

(*a*) The size and number of ventilators is determined by the size of the area to be ventilated.

(*b*) The minimum net open area should be ¼ square inch per square foot of ceiling area.

(*c*) Most louver frames are usually 5 inches wide.

(*d*) Back edge should be rabbeted out for a screen or door, or both.

(*e*) Three-quarter-inch slats are used and spaced about 1¾ inches apart.

(*f*) Sufficient slant or slope to the slats should be provided to prevent rain from driving in.

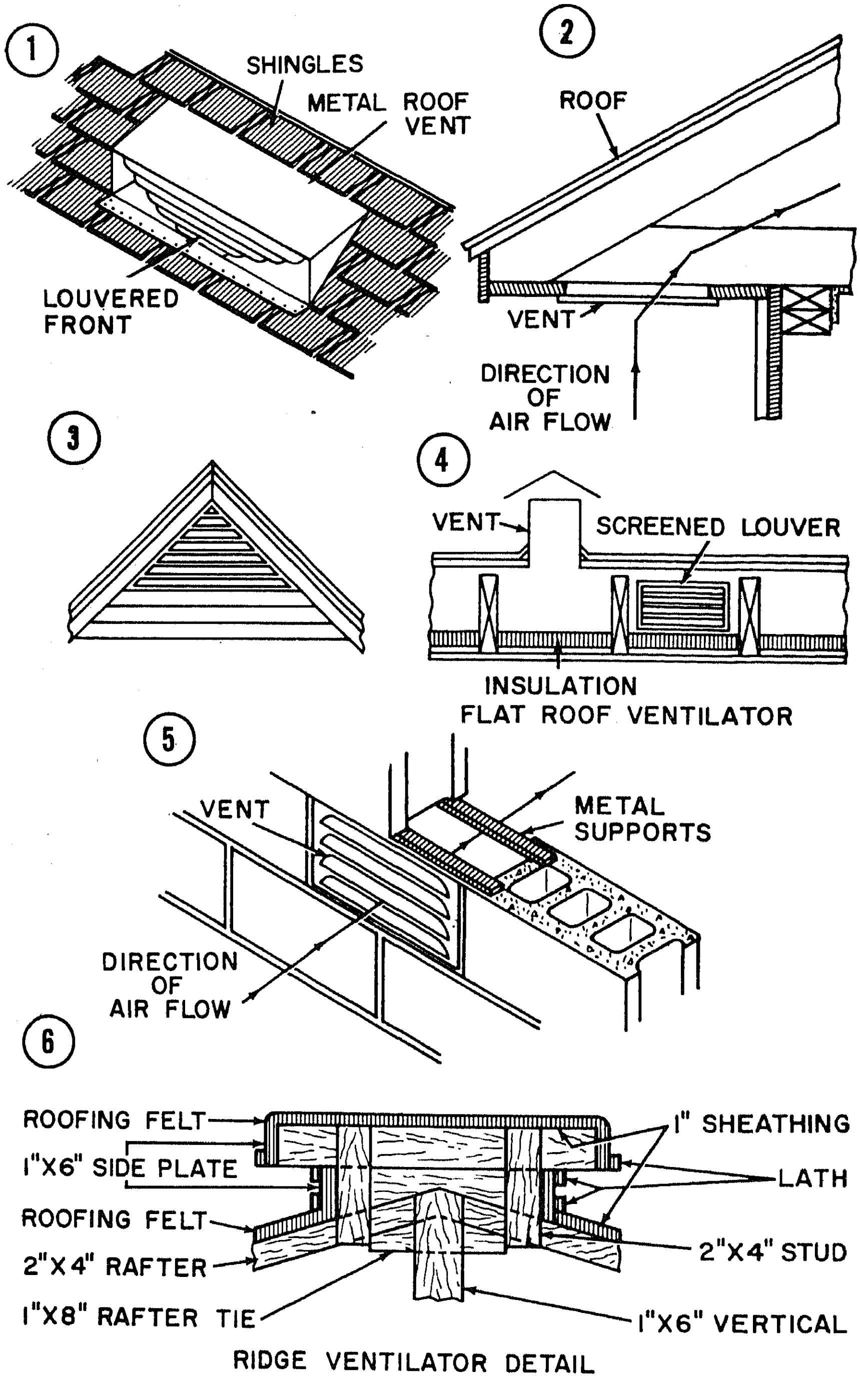


Figure 79. Types of ventilators.

(g) For best operation, upper structure louvers are placed as near the top of the gable as possible.

(3) *Crawl-space ventilation.* Crawl spaces under foundationed but basementless structures should be well ventilated. Air circulation under the floors prevents excessive condensation, which causes warping, swelling, tw and rotting of the lumber. These vents are usually "foundation louvers" (5, fig. 79) and are used as space ventilators. They are set into the foundatio is being built. A good foundation vent should be eq with a copper or bronze screen and adjustable sl for opening and closing the louver. The sizes f louvers should be figured on the same basis as that for upper structure louvers—¼-inch for each squa of underfloor space.

57. Steps and Stairs

Stairwork is made up of the framing on the sides, kn stringers or carriages, and the steps, known as treads. Son pieces are framed into the stairs at the back of the treads, pieces are known as risers. Usually basement stairs have o stringers and treads. The stringers or carriages may consist material 2 or 3 inches thick and 4 or more inches wide which are cut to form the step of the stairs, or blocks may be nailed on to form the steps. There are usually three of these stringers to a stair, one at each of the two outer edges and one at the center. The floor joists must be properly framed around the stair well, or wellhole, in order to have sufficient space for the erection of the stair framing and the finished trim of the entire staircase. Stairs leading from the first floor to the basement are relatively easy to build.

a. The step or stair stringer may be made of 2 by 4's, with triangular blocks nailed to one edge to form the stringer. The blocks are cut from 2 by 6's and nailed to the 2 by 4, as shown in 1, figure 80. The step stringers are fastened at the top and bottom as shown in 2, figure 80. Figures 80 and 81 show the foundation and give the details of the sizes of the step treads, handrails, the methods of installing them, and the post construction. This type of step is most common in field construction.

b. When timbers heavier than 2 by 4's are used for stringers, they are laid out and cut as shown in figure 82.

c. To frame simple, straight string stairs, take a narrow piece of straight stock, called a story pole, and mark on it the distance from the lower floor to the upper floor level. This is the lower room

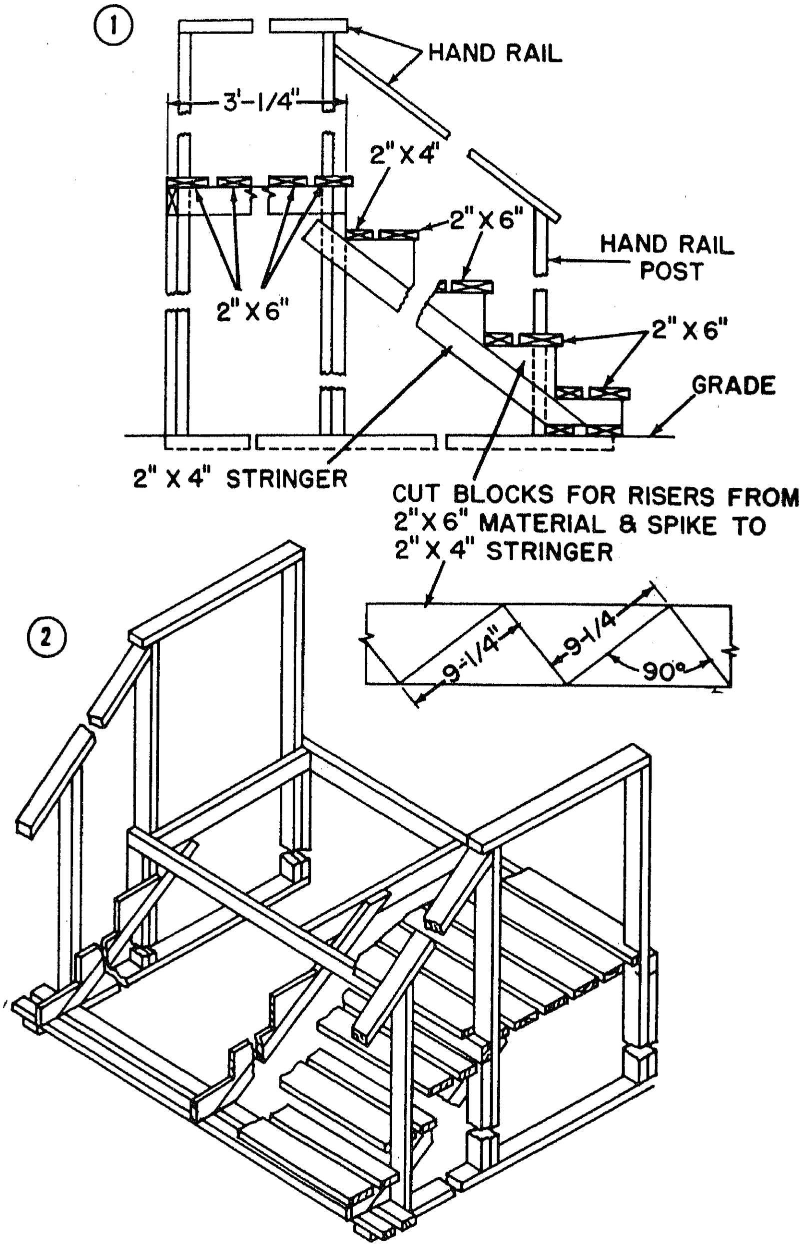


Figure 80. Step details.

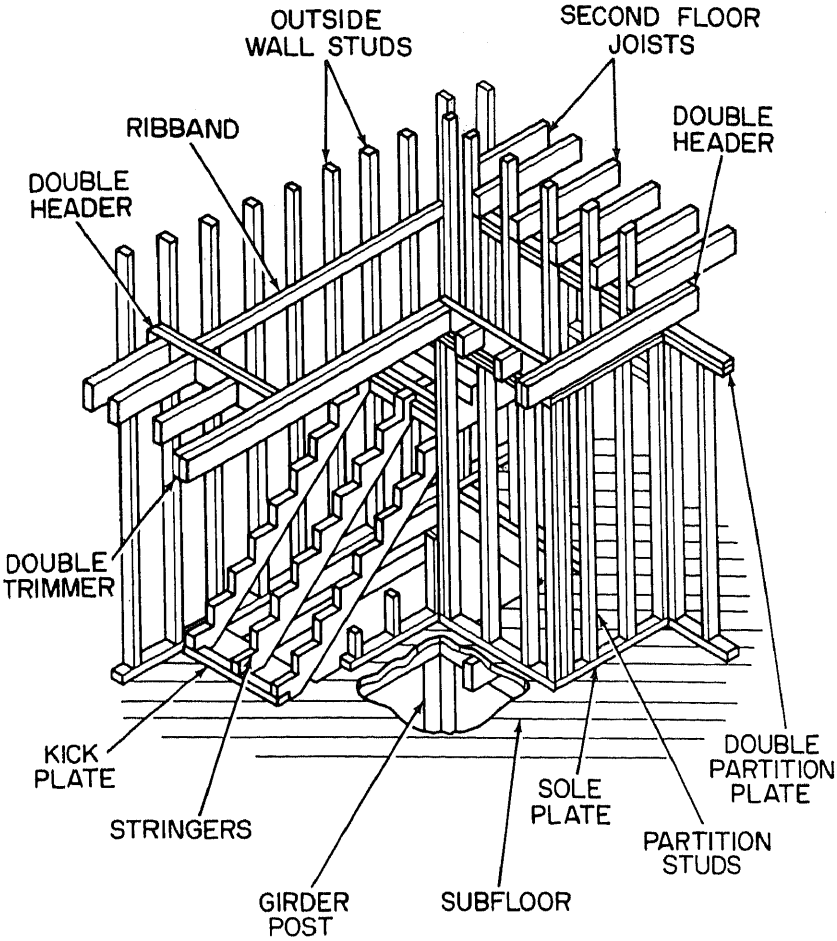


Figure 81. Details of complete stair construction.

height, plus the thickness of the floor joists, and the rough and finished flooring. It is also the total rise of the stairs. If it is kept in mind that a flight of stairs forms a right angled triangle (fig. 83), with the rise being the height of the triangle, the run being the base of the triangle, and the length of the stringers being the hypotenuse of the triangle, it will help in laying out the stair distances. Set dividers at 7 inches, the average distance from one step to another, and step off this distance on the story pole. If this distance will not divide into the length of the story pole evenly, adjust the divider span slightly and again step off this distance on the story pole. Continue this adjusting and stepping off until the story pole is marked off evenly. The span of the dividers must be near 7 inches and represents the rise of each step. Count the num-

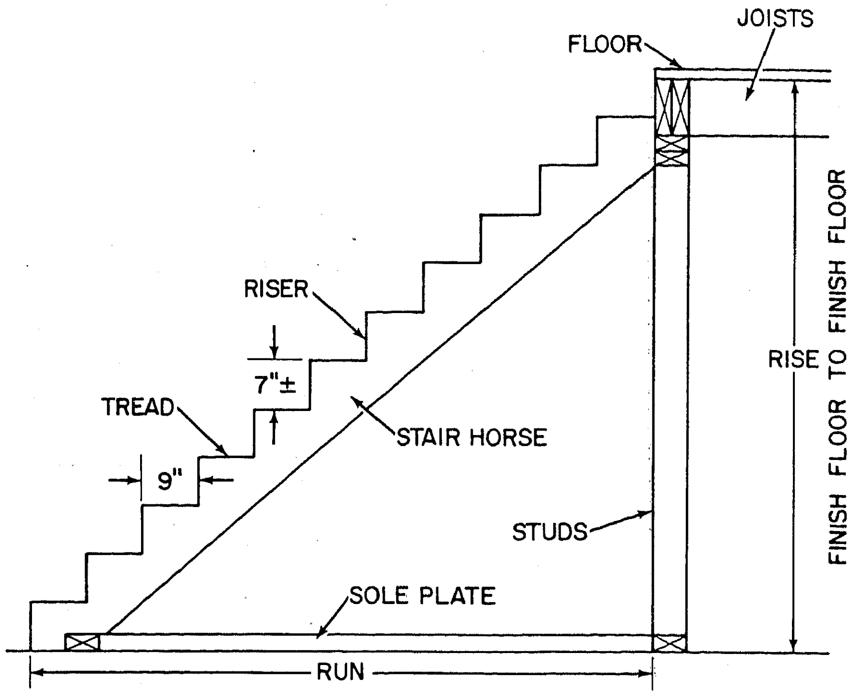


Figure 82. Method of laying out stair stringers.

ber of spaces stepped off evenly by the dividers, on the story pole. This will be the total number of risers in the stairs.

d. Measure the length of the wellhole for the length of the run of the stairs. This length may also be obtained from the details on the plans. The stair well length forms the base of a right-angled triangle. The height of the triangle and the base of the triangle have now been obtained.

e. To obtain the width of each tread, divide the number of risers, less one—since there is always one more riser than tread—into the run of the stairs. The numbers thus obtained are to be used on the steel square in laying off the run and rise of each tread and riser on the stringer stock (fig. 82). These figures will be about 7 inches and 10 inches, respectively, since the ideal run and rise totals 17 inches. Lay off the run and rise of each step on the stringer stock equal to the number of risers previously obtained by dividing the story pole into equal spaces. The distance of the height, base, and hypotenuse of a right-angled triangle are thus obtained.

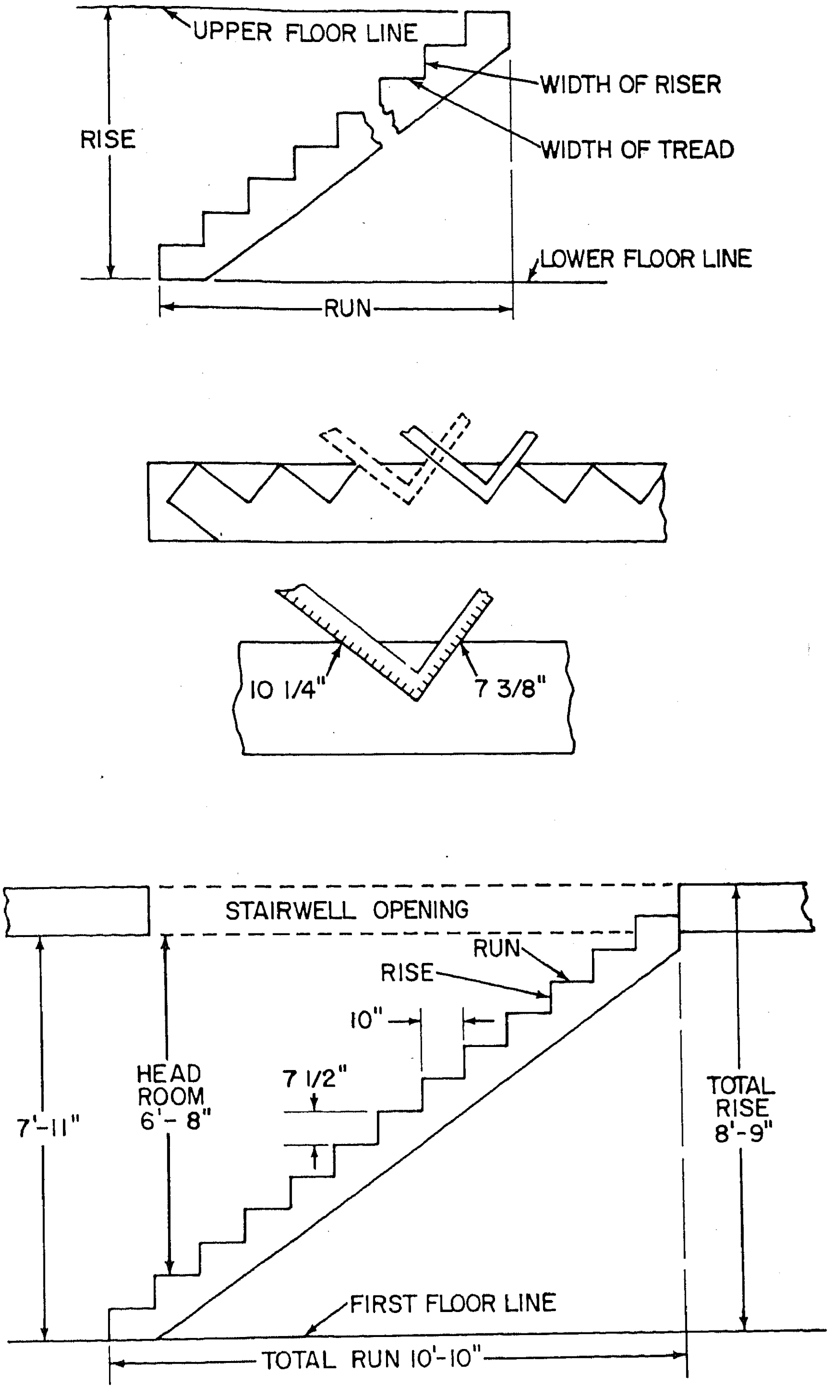


Figure 83. Principal parts of stair construction.

CHAPTER 6

COVERINGS

Section I. FLOORS

58. Subfloors

After the foundation, the floor is constructed. Subfloor, if used, is laid diagonally on the joists and nailed with 8- or 10-penny nails, the number of nails depending upon the width of the boards. The floor joists form a framework for the subfloor. This floor is called the rough floor, or subfloor, and may be visioned as a large platform covering the entire width and length area of the building. Two layers or coverings of flooring material, subflooring and finished flooring, are placed on the joists. Boards 8 inches wide or over should have three or more nails per joist. Where the subfloor is over 1 inch thick, larger nails should be used. By the use of subflooring, floors are made much stronger since weight is distributed over a wider area. Figure 30 shows the method of laying a subfloor. It may be laid before or after the walls are framed, preferably before; so it can then be used as a floor to work on while framing the walls.

59. Finish Floors

a. General. A finish floor in the theater of operations, in most cases, is of ¾-inch material, square edged (fig. 84) or tongued and grooved (fig. 85), and varying from 3¼ to 7¼ inches wide. It is laid directly on floor joists or on a subfloor and nailed with 8-penny common nails in every joist. When laid on a subfloor, it is best to use building paper between the two floors to keep out dampness and insects. In warehouses, where heavy loads are to be carried on the floor, 2-inch material should be used. The flooring, in this case, also is face-nailed with 16- or 20-penny nails. It is not tongued and grooved and ranges in width from 4 to 12 inches. The joints are made on the center of the joist.

b. Wooden Floors. Wooden floors must be framed with one main purpose in mind—they must be strong enough to carry the load. The type of building and the use for which it is intended determines the general arrangement of the floor system, thickness of the sheathing, and approximate spacing of the joists.

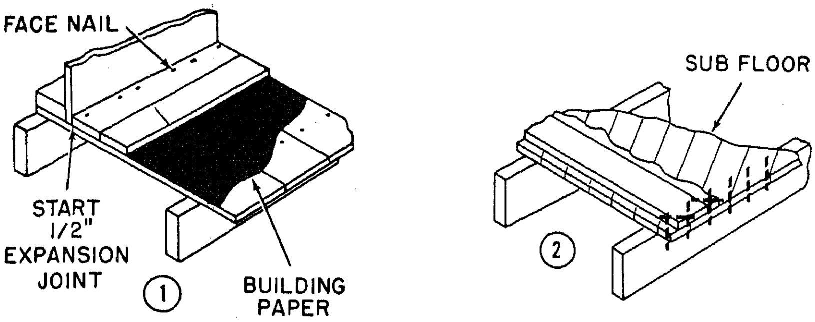


Figure 84. Methods of nailing square edged flooring.

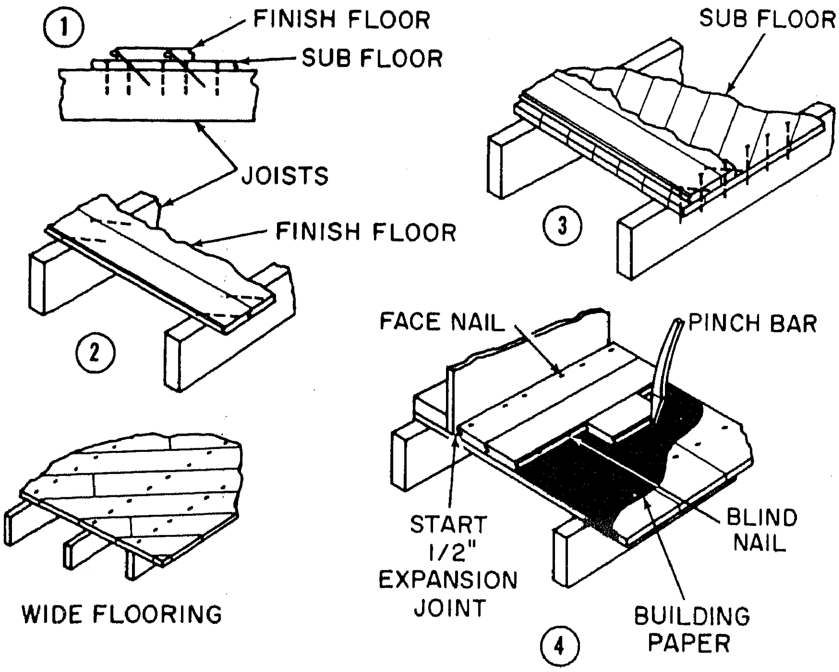


Figure 85. Methods of nailing tongued and grooved flooring.

c. Concrete Floors. Concrete floors may be constructed for shops where earthen or wooden floors are not suitable, such as in repair and assembly shops for airplanes and heavy equipment and in certain kinds of warehouses. These floors are made by pouring the concrete on the ground after the earth has been graded and tamped. This type of floor is likely to be damp unless protected. Drainage is provided, both for the floor area and for the area near the floor, to prevent flooding after heavy rains. The floor should be reinforced with steel or wire mesh. Where concrete floors are to be

poured, a foundation wall may be poured first and the floor poured after the building is completed. This gives protection to the concrete floor while it sets and eliminates the waiting period before construction of the building.

d. Miscellaneous Types of Floors. Miscellaneous floors may include earth, adobe brick, duckboard, or rushes. Utilization of miscellaneous flooring is usually determined by a shortage of conventional materials, the need to save time or labor, the extremely temporary nature of the facilities, or the special nature of the structure. The selection of material is usually determined by availability. Duckboard is widely utilized for shower flooring; earthen floors are common and conserve both materials and labor if the ground site is even without extensive grading. Rush or thatch floors are primarily an insulating measure and require frequent replenishing.

e. Supports. In certain parts of the floor frame, in order to support some very heavily concentrated load or a partition wall, it may be necessary to double the joist or to place two joists together (fig. 86).

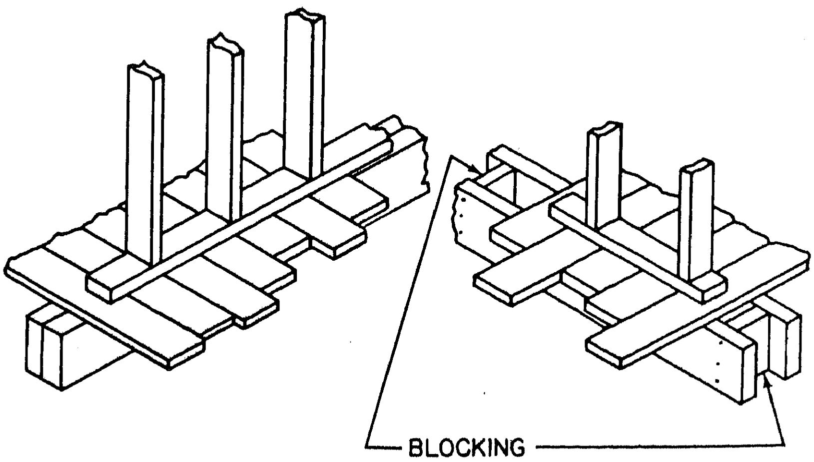


Figure 86. Reinforced joists.

Section II. WALLS AND CEILINGS

60. Exterior Walls

a. General. The exterior surfaces of a building usually consists of vertical, horizontal, or diagonal sheathing and composition, sheet-metal, or corrugated roofing. However, in theaters of operation the materials prescribed by typical plans are not always available and substitutes or improvised materials must be provided

from local sources. Concrete block, brick, rubble stone, metal, or earth may be substituted for wood in treeless regions. In the tropics, improvised siding and roofs can be made from bamboo and grasses. Roofing felt, sandwiched between two layers of light wire mesh, may serve for wall and roof materials where climate is suitable. Refer to TM 5–302 for details on substitute, expedient, and improvised construction.

b. Sheathing. Sheathing is nailed directly onto the fr
of the building. Its purpose is to strengthen the building
vide a base wall onto which the finish siding can be naile
as insulation, and in some cases to be a base for further in
Some of the common types of sheathing include—

(1) Wood, 13/16-inch thick by 6, 8, 10, or 12 inch wide
common square or matched-edge material. It
nailed on horizontally or diagonally.

(2) Gypsum board wall-sheathing, ½-inch thick by
width and 8 feet long.

(3) Fiberboard, 25/32-inch thick by 24- and 48-inch
and 8, 9, 10, and 12 feet long.

(4) Plywood, 5/16, 3/8, 1/2, 5/8-inch thick by 48 inch wide and 8, 9, 10, and 12 feet long.

c. Application.

(1) Wood wall sheathing can be obtained in almost all widths, lengths, and grades. Generally, widths are from 6 to 12 inches, with lengths selected for economical use. Almost all solid wood wall sheathing used is 13/16-inches thick and either square or matched edge. This material may be nailed on horizontally or diagonally (fig. 87). Diagonal application contributes much greater strength to the structure. Sheathing should be nailed on with three 8-penny common nails to each bearing if the pieces are over 6 inches wide. Wooden sheathing is laid on tight, with all joints made over the studs. If the sheathing is to be put on horizontally, it should be started at the foundation and worked toward the top. If it is to be put on diagonally, it should be started at the corners of the building and worked toward the center or middle of the building.

(2) Gypsum-board sheathing (fig. 88) is made by casting a gypsum core within a heavy water-resistant fibrous envelope. The long edges of the 4 by 8 foot boards are tongued and grooved. Each board is a full ½-inch thick. Its use is mostly with wood siding that can be nailed directly through the sheathing and into the studs. Gyp-

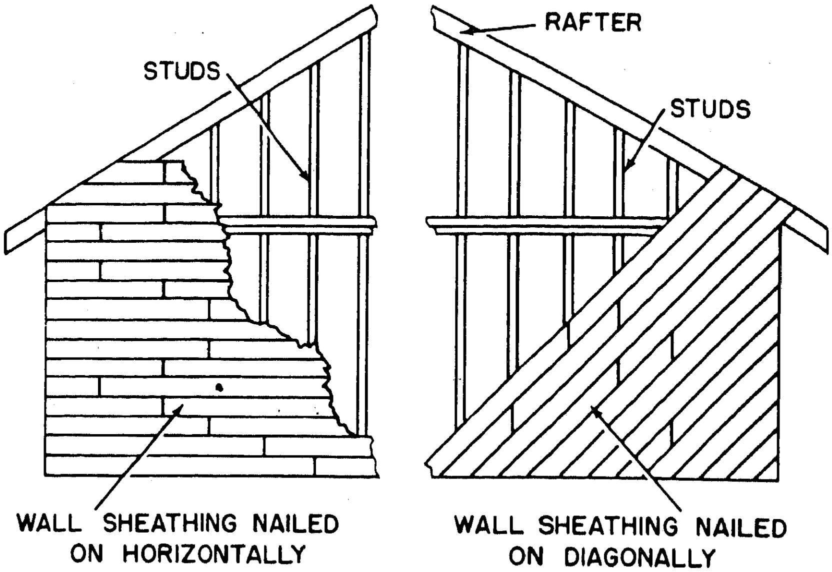


Figure 87. Diagonal and horizontal wooden sheathing.

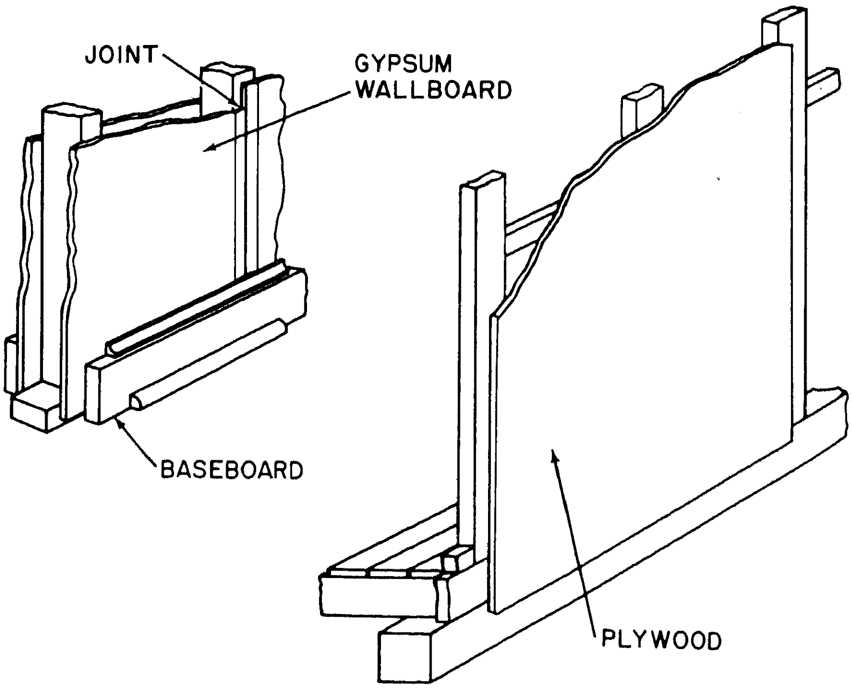


Figure 88. Gypsum and plywood sheathing.

sum sheathing is fireproof, water resistant, and windproof; does not warp nor absorb water; and does not require the use of building papers.

(3) Plywood as a wall sheathing (fig. 88) is highly recommended by its size, weight, stability, and structural properties, plus the ease and rapidity of application. It adds considerably more strength to the frame than does diagonally applied wood boards. When plywood sheathing is used, corner bracing can be omitted. Large size panels effect a major saving in the time required for application and still provide a tight, draft-free installation that contributes a high insulation value to the wall. Minimum thicknesses of plywood wall sheathing is $\frac{5}{16}$-inch for 16-inch stud spacing and $\frac{3}{8}$-inch for 24-inch stud spacing. The panels should be installed with the face grain parallel to the studs. However, a little more stiffness can be gained by installing them across the studs, but this requires more cutting and fitting. Use 6-penny common nails for $\frac{5}{16}$-, $\frac{3}{8}$-, and $\frac{1}{2}$-inch panels and 8-penny common nails for $\frac{5}{8}$- and $\frac{13}{16}$-inch panels. Space the nails not more than 6 inches on center at the edges of the panels and not more than 12 inches on center elsewhere.

d. Vertical Wooden Siding. This type of coverage is nailed to girts. The cracks are covered with wood strips called battens. The sheathing is nailed securely with 8- or 10-penny nails. The vertical sheathing requires less framing than siding since the sheathing acts as a support for the plate. To make this type of wall more weatherproof, some type of tar paper or light roll roofing may be applied over the entire surface and fastened with roofing nails and battens (fig. 89).

e. Horizontal Wooden Siding. Wood siding is lumber cut to various patterns and sizes to be used as the finished outside surface of a structure. Quite often it is called weatherboarding and its purpose is to keep out the wind and weather, to help keep a building warm on the inside, and to increase the strength of its construction. The selection of the kind and grade of siding for outside wall coverings is important. It should be of a decay-resisting species that will hold tight at the joints and take and hold paint well. It should by all means be well seasoned lumber. Siding is made in sizes ranging from $\frac{1}{2}$ inch by $\frac{3}{4}$ inch by 12 inches. There are two principal types of siding (fig. 1) : bevel siding and drop siding.

(1) *Beveled siding* (fig. 1). Beveled siding is made by sawing a thick board lengthwise at an angle, producing two

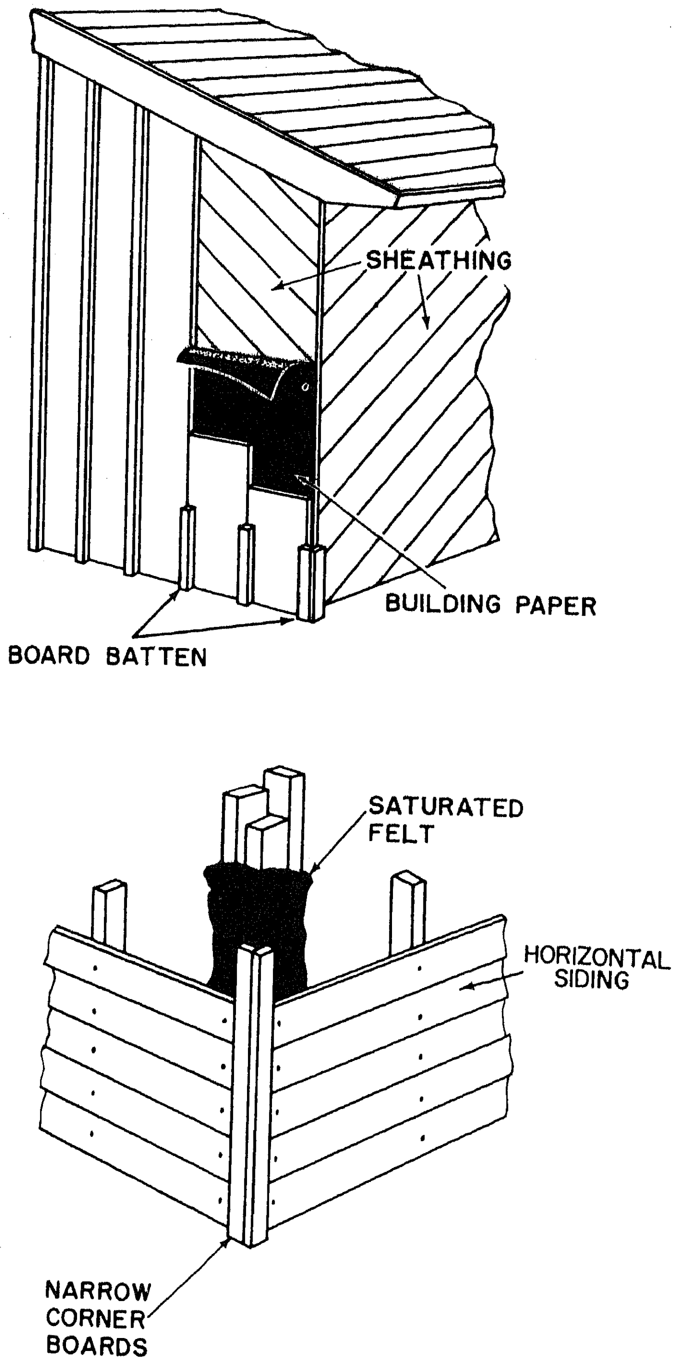


Figure 89. Vertical and horizontal wooden siding.

beveled boards thin at the top edge and thick at the butt. It is the most common form of wood siding and comes in widths from 4 to 12 inches. The boards are lapped about 1 inch for narrow widths, and 2 inches and over fo wide types. They are usually nailed at the butt edg through the tip edge of the board below. Very n siding is quite often nailed near its thin edge simila shingles. It is nailed to solid sheathing over which ing paper has been attached. Window and door e: are first framed; the siding butts against the ed; these. Corners are either mitered, or corner boar(first nailed to the sheathing, and the siding fitted a; the edges.

(2) *Drop siding* (fig. 1). Drop siding is designed to b(as sheathing and siding combined, or with se] sheathing. It comes in a wide variety of face profil(is either shiplapped or tongued and grooved. If use(combined sheathing and siding material, tongu(grooved lumber is used with the tongue up and : directly to the studs. When sheathing is not use(door and window casings are set after the siding i If sheathing is first used and then building paper, siding is applied like beveled siding, after window door casings are in place.

(3) *Corrugated metal sheets.* Corrugated metal is used extensively as wall coverage since little framing, time, and labor are required to install it. It is applied vertically and nailed to girts, the nails being placed in the ridges. Sheathing can be used behind the iron with or without building paper. Since tar paper used behind metal will cause the metal to rust, a resin-sized paper should be used.

(4) *Building paper.*

(*a*) Building paper is of several types according to content, the most common being the resin-sized. It is generally red or buff in color (sometimes black) and comes in rolls, usually 36 inches wide, with each roll containing 500 square feet and weighing from 18 to 50 pounds. Ordinarily, it is not waterproof. Another type is of heavy paper saturated with a coaltar product and is sometimes called sheathing paper. It is waterproof and provides protection against heat and cold.

(*b*) In wood-frame buildings, whether covered with siding, shingles, or iron, building paper is used when it is desired to protect against heat, cold, or dampness. In

applying it to side walls, with or without sheathing, care should be taken not to tear the paper. The laps should be made toward the ground and nailed with roofing nails at the laps. The waterproof type paper is used also in the built-up roof where the roof is nearly flat. Several layers are used with tar between each layer.

61. Interior Walls and Partitions

a. Wall and Partition Coverings. Wall and partition coverings are divided into two general types—wet wall material, generally plaster; and dry wall material including wood, plaster board, plywood, and fiber board. Only dry wall material will be covered in this manual. For lathing and plastering, see TM 5–621.

b. Dry Wall Materials.

(1) Dry wall material usually comes in sheets ½ inch thick and 4 x 8 feet in size. It is normally applied in either single or double thickness with panels placed as shown in figure 92. When covering both walls and ceilings, always start with the ceiling (par. 62). Annular ringed nails should be used for applying finished-joint drywall to reduce nail popping.

(a) *Applying single-thickness dry wall.*

1. Start in one corner and work around the room, making sure that joints break at the centerline of a stud.

2. Use ½-inch thick recessed-edge wallboard and span the entire height of the wall if possible.

3. Using 13-gage nails, 1⅜ inches long, start nailing at the center of the board and work outward. Space the nails ⅜ inch in from the edge of the board and about 8 inches apart. Dimple nails below surface of panel with a ballpeen hammer. Be careful not to break the surface of the board by the blow of the hammer.

4. Procedures for cutting and sealing wallboard are covered in (3) below.

(b) *Applying double-thickness dry wall.* The double-thickness dry-wall system calls for two layers of wallboard, each ⅜ inch thick. The base layer is nailed vertically to the studs and the face layer is applied horizontally over the base layer with an adhesive which makes the two adhere to each other. The joints are sealed with a reinforcing tape and a cement especially designed for this purpose.

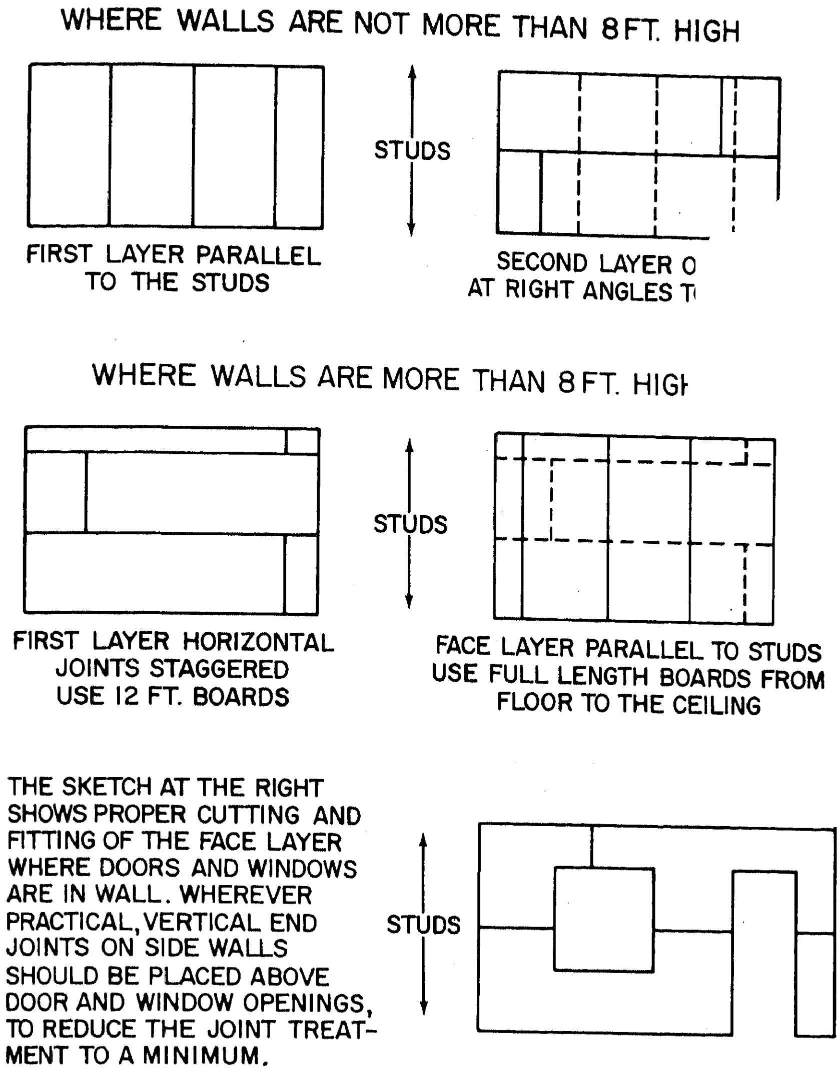


Figure 90. Placing wallboard.

(2) Fit dry wall materials to rough or uneven walls in the following manner:

(*a*) Place a piece of scrap material in the angle (fig. 93) and scribe it to indicate the surface peculiarities.

(*b*) Place the scribed strip on the wallboard to be used, keeping the straight edge of the scrap material parallel with the edge of the wallboard.

(*c*) Saw both the scrap and walboard along the scribed line.

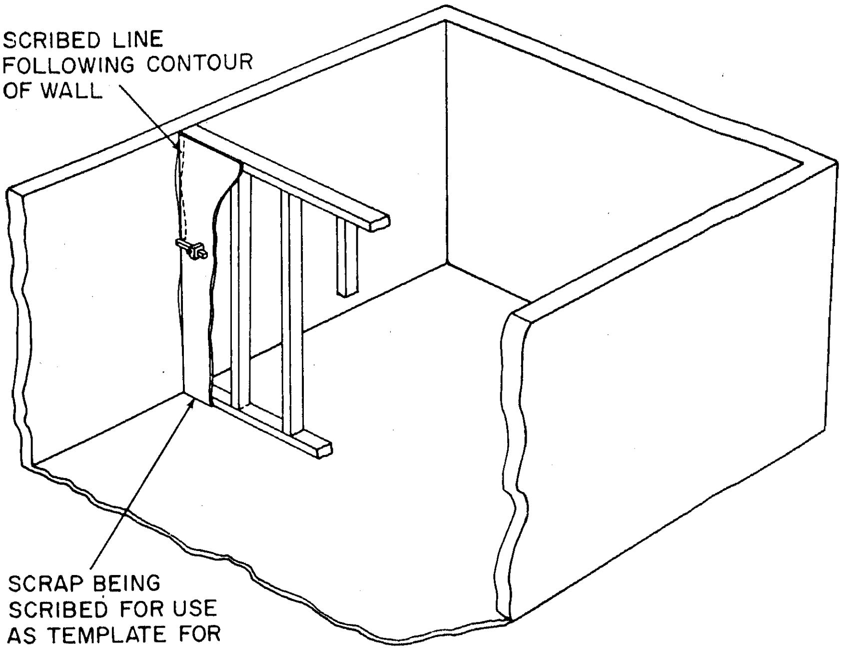


Figure 91. Fitting single-piece wallboard partition to walls.

(3) Cut panels by sawing, or by scoring with an awl and snapping over a straight edge (fig. 92). *Cut with finish side up to avoid damaging surface.* Cut openings for pipe and electrical receptacles with a keyhole saw. Nail panels to wall studs with 13-gage nails, 8 inches on centers. *All panel end joints must center on studs.* Cover nails with cement. Joints may be left open, beveled, lapped, filled, covered with battens or moldings, or treated with cement and tape. The treatment of joints varies slightly with different materials. Generally, all cracks over 1/8 inch must be filled with special crack filler before joint cement is applied. The cement is spread over joints with a plasterer's trowel. Apply the cement evenly and thin (feather) edges on surface of wall panel. Fill channels in recessed edges with cement, carrying it 1-inch past channel edges. At corners, apply cement in a channel-wide band and feather edges. Press perforated tape into wet cement and smooth tape down with trowel. Clean off excess cement. At corners, fold tape down center before applying, and smooth each side of corner separately when applied. When cement is dry, apply a second coat of thinned cement to hide tape. Feather the edges carefully

to preserve flat appearance of wall. When the final coat is dry, smooth the joint with sandpaper.

62. Ceilings

Ceilings may be constructed of wood or wallboard. Wood ceilings in present day practice utilize 4 by 8 foot plywood sheets in ¼ and ⅜ inch thicknesses. Normal ceiling joist spacing of 16 and 24

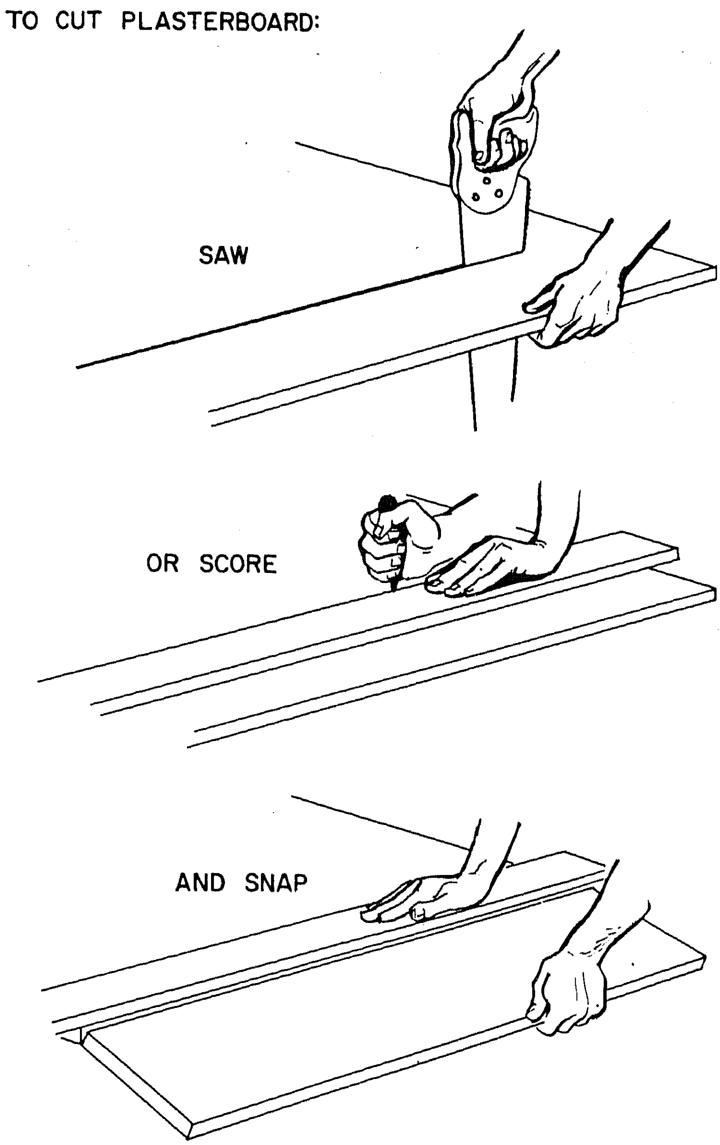


Figure 92. Cutting wallboard partition.

inches on center is sufficient for nailing support. Plywoo may be exposed, covered with wood molding, bevel ec utilize metal divider strip moulding.

a. The size and shape of the ceiling will largely determin of three methods of applying wallboard will be used, as sh figure 93. In all cases, the facelayer is applied at right ar the direction of the first layer. When the number of pie their sizes have been determined, proceed as follows:

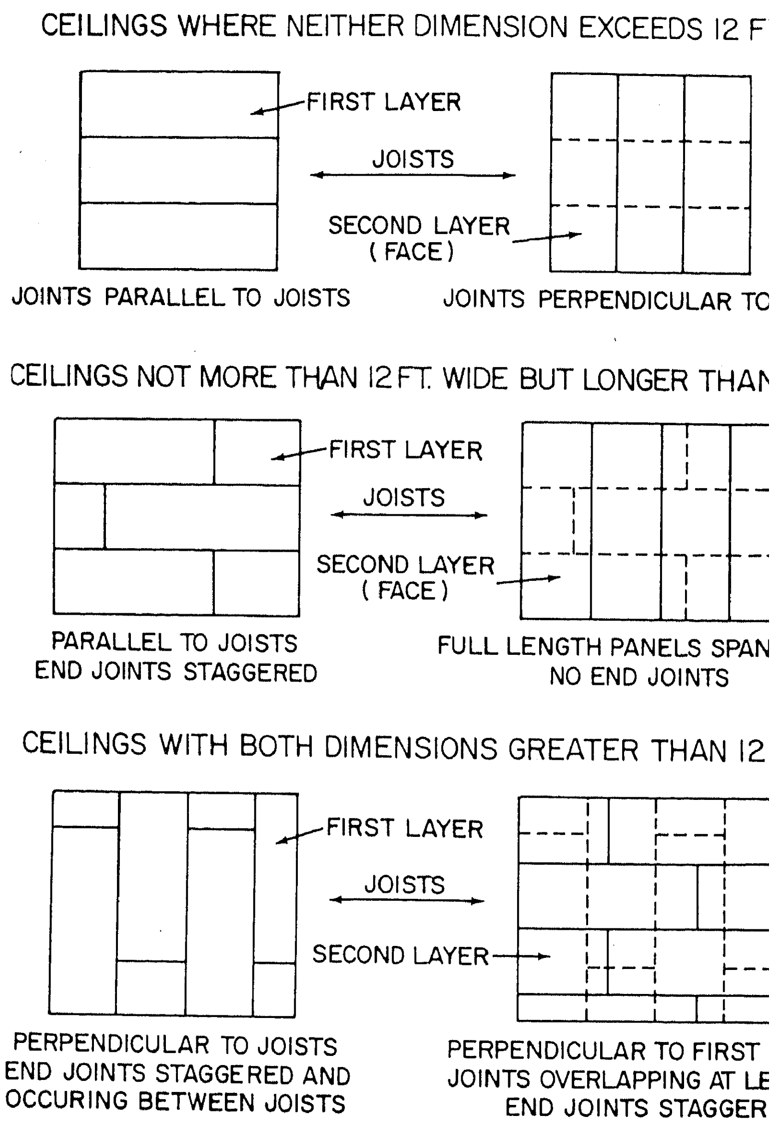


Figure 93. Application of wallboard to various types of ceilings.

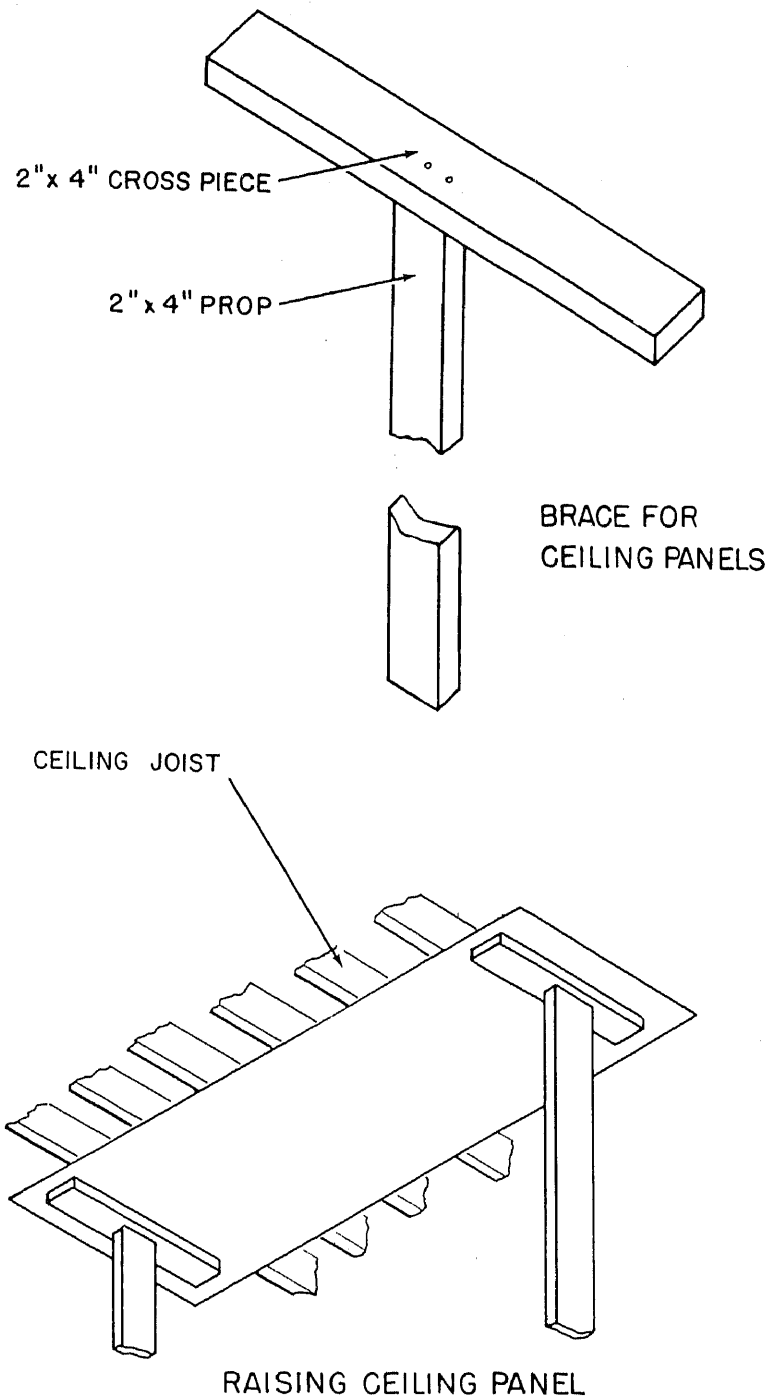


Figure 94. Raising ceiling panels.

(1) Even if the walls are to be covered, start by applying the first piece of base wallboard to the ceiling.

(2) Nail on the first layer parallel to the ceiling joists. Span the entire width of the room with one piece if possible. If this is not possible, stagger the end joints.

(3) Start the application of the face layers. Nail all face layers on at right angles to the base layers. Special adhesive, usually supplied with the boards, is mixed and spread on the backs of the face layer with a notched trowel. This "buttered side" is then placed against the base coat and nailed.

(4) Use only enough nails in the face layer to hold it in place. Drive the nails in so that the heads are slightly below the surface of the wallboard.

(5) Seal all joints and nail holes as prescribed in paragraph 61.

b. Paneling the Ceiling. Starting at an existing wall, raise first panel into position. Use improvised braces (fig. 94) to hold panel in place. Nail panel to ceiling joists. The ceiling joists at either end of panel requires 8-inch nail spacing. Fit panels flush, one to the other, covering entire ceiling.

Section III. ROOF COVERING

63. Types

Of the many types of roof coverings which are used, this manual covers only the types used by the Army in the theater of operations —corrugated sheet metal and prepared roofing.

a. Corrugated Sheet Metal Roofing. The corrugated sheet metal covering of the standard type has corrugation 2½ inches wide and ⅝ inch deep. The sheets are 26 inches wide and vary in length from 6 to 12 feet. They are either painted or galvanized, to prevent corrosion.

b. Prepared Roofing. There are several brands of prepared roofing, all similar in type. They are composed of either paper, felt, or asbestos paper and are saturated with different brands of waterproofing compounds. They are assembled at the factory, along with asphalt cement, into strips about 1 yard wide and 12 yards long. These roofing materials are equivalent to 2-ply or 3-ply built-up roofing (built-up roofing consists of layers of tar paper laid on flat roofs and bound together with layers of tar). The roofings may have a plain surface, or they may be surfaced with crushed slate, sand mica, or other mineral surfacing.

64. Installation

a. Corrugated Roofing. Corrugated sheet metal may be nailed to either solid or slatted wood sheathing, or it may be supported directly by wood purlins spaced from 1 to 3 feet apart. The sheets are overlapped one or two corrugations on the sides and 6 or 8 inches on the ends, depending upon the slope of the roofs. To nail this type of roofing securely, a special type nail should be used, such as lead-headed or galvanized nails, with neoprene or lead washers. Common wire nails may be used but they rust easily and may cause slight leaks, while lead-headed or galvanized nails seal the hole when they are driven into the metal. The side laps should be nailed every 2 feet, while the end laps should be nailed every foot. This type of roofing should not be used on roofs with slopes of less than 4 inches per foot. Corrugated aluminum roofing should never be used in direct contact with any iron or steel.

b. Prepared Roofing. Prepared roofing is nailed to roofs which are sheathed solidly. Special nails with large heads are used along the edges, 3 inches on centers. The edges of the roofing are lapped not less than 4 inches, depending upon the slope of the roof. These edges are cemented with tar before nailing (fig. 95). The end laps should be at least 8 inches and are cemented in place. Prepared roofing may be laid parallel either to the eaves or to the slope (fig. 95). This type of roof may be used on any slope greater than 2 inches per foot. On flatter slopes, great care must be taken to have the joint well cemented. To save time and labor, the roofing at the eaves and at rake or gable ends may be fastened with wooden strips.

c. Flashing. Where two roofs come together at right angles, a valley is formed and some type of additional covering must be used along the joint to provide adequate waterproofing. A hasty and yet satisfactory expedient is to use two layers of roll roofing in the valley, one 14 inches and the other 22 inches wide. A strip of sheet metal 22 inches wide also may be used (6 and 7, fig. 95). The metal or roll roofing material used to cover the joining roofs is cut back from the center of the valley 3 or 4 inches. The joint formed when a roof butts against a vertical wall is flashed as shown in 8 and 9, figure 95. Metal or roll roofing may be used as the flashing. If the vertical wall is not sheathed, a 2- by 4-girt is installed between the studs, as shown in 9, figure 95, to support the flashing. Roll roofing may be used as a continuous piece for roofing and flashing.

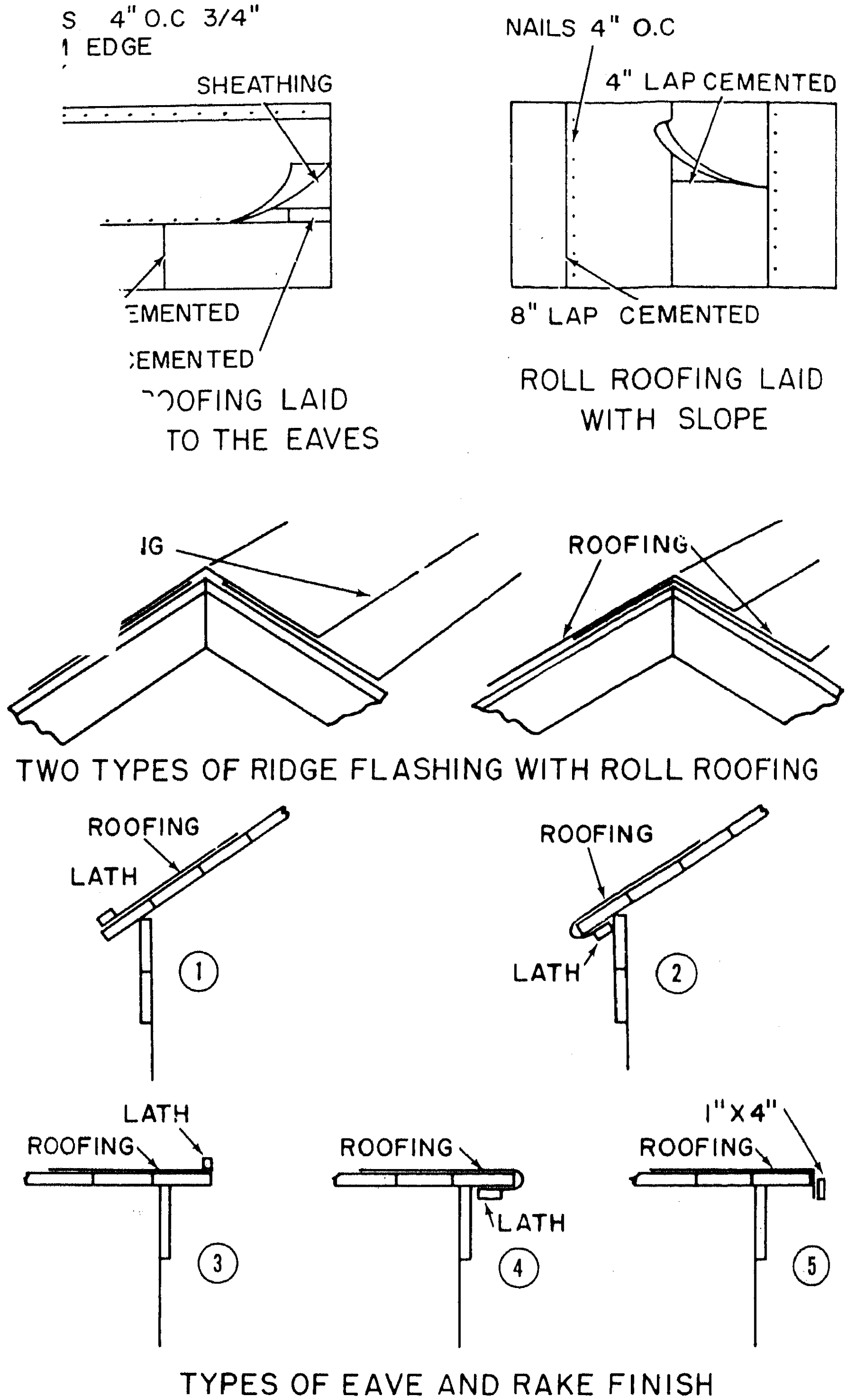


Figure 95. Types of roof finish and flashing details.

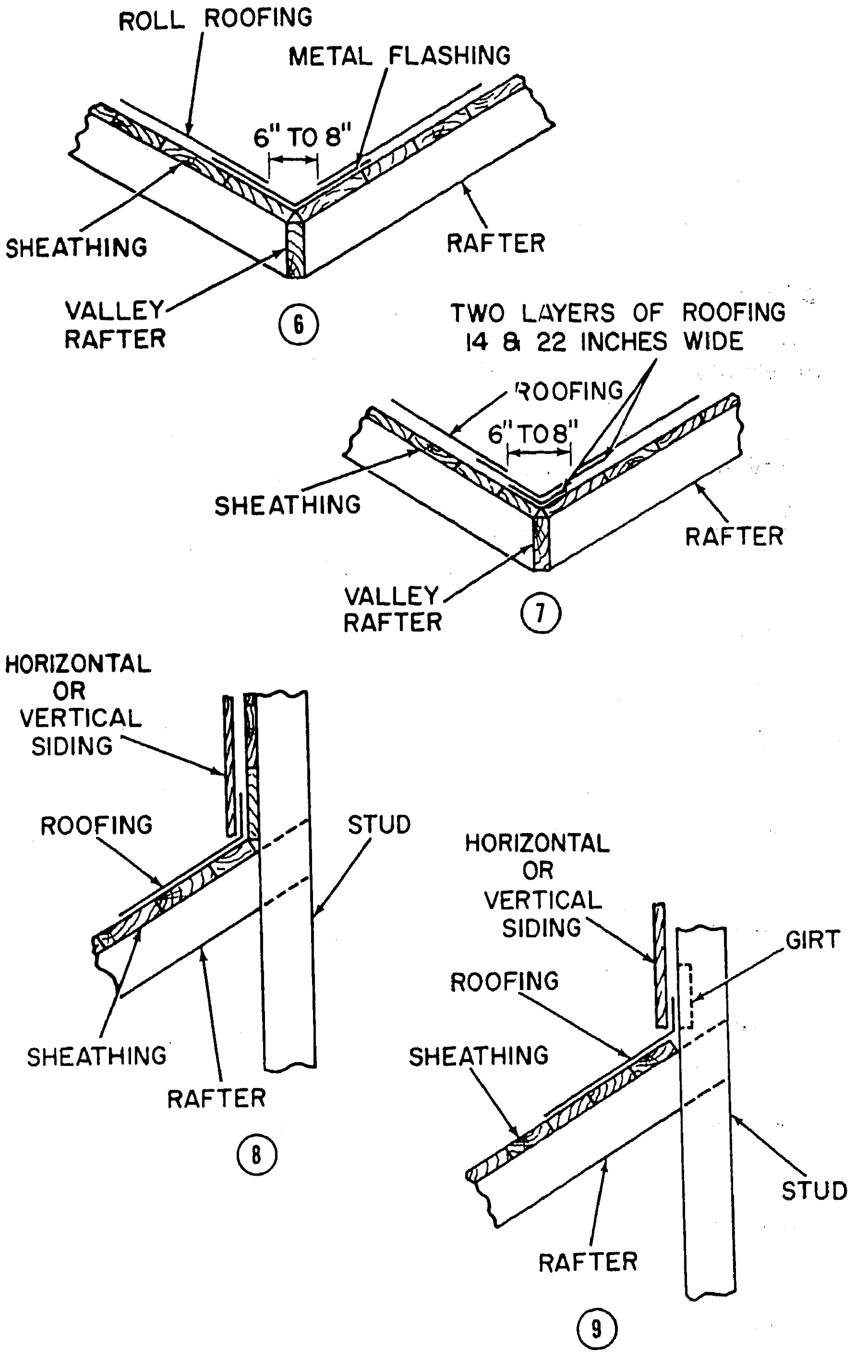


Figure 95—Continued.

CHAPTER 7
ACCESSORIES

Section I. DOORS

65. Job-Built Doors

a. Types. Doors, both exterior and interior, are classified as three types; batten, panel, and flush, with a few variations in each type (fig. 96). The batten door is the most commonly used and the most easily constructed type of job-built door. It can be made in several ways, one of the simplest consisting of diagonal boards nailed together as two layers, each layer at right angles to the other. Constructed in this manner, this type of door frequently is used as the core for metal-sheathed fire doors. Another type of batten door is made up of vertical boards tongued and grooved or shiplapped and held rigid by crosspieces. These crosspieces are from two to four in number, and may or may not be diagonally braced. The crosspieces are called ledgers. If two additional pieces forming the sides of the door and corresponding to the ledgers are used, these are known as the frames.

b. Construction. In hasty construction, the carpenter who erects the building makes the door from several boards with ledgers and braces as shown in figure 97. These boards are 1 by 6's, laid close together and nailed to ledgers. The ledgers are placed with their edge 6 inches from the ends of the door boards. A diagonal is placed between the ledgers, beginning at the top ledger end opposite the hinge side of the door and running to the lower ledger diagonally across the door. If the door is used as an outside door, roofing felt is used to cover the boards on the weather side. The ledgers are nailed over the felt. Wooden laths are nailed around the edges and across the middle of the door to hold the roofing felt in place. The ledgers on doors are 1 by 6's and are nailed securely to the door boards. In hanging these doors, T-strap hinges are used. The hinges are fastened to the ledgers of the door and to the hinge blocks on the door casing or post. One quarter of an inch clearance should be left around the door to take care of expansion.

66. Mill-Built Doors

a. Types.

(1) *Paneled doors.* Paneled doors are made in a variety of

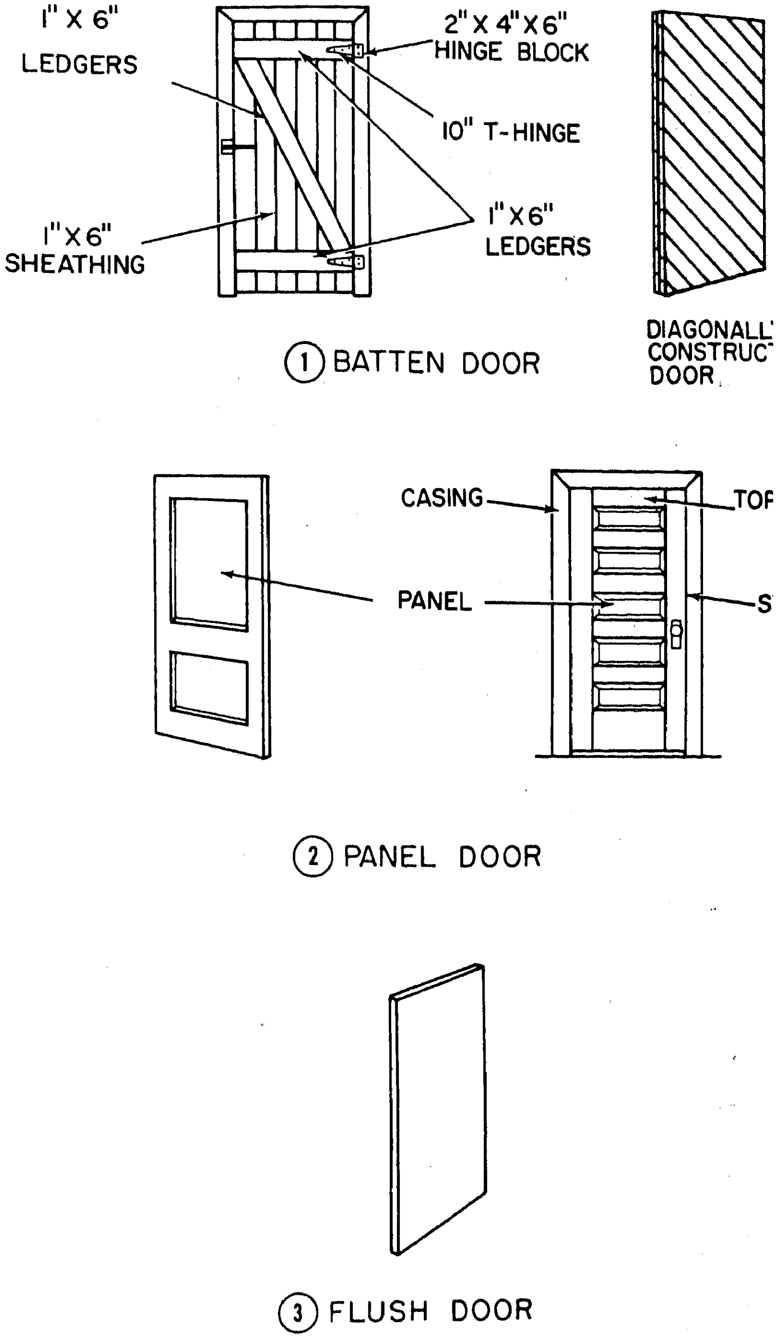


Figure 96. Types of doors.

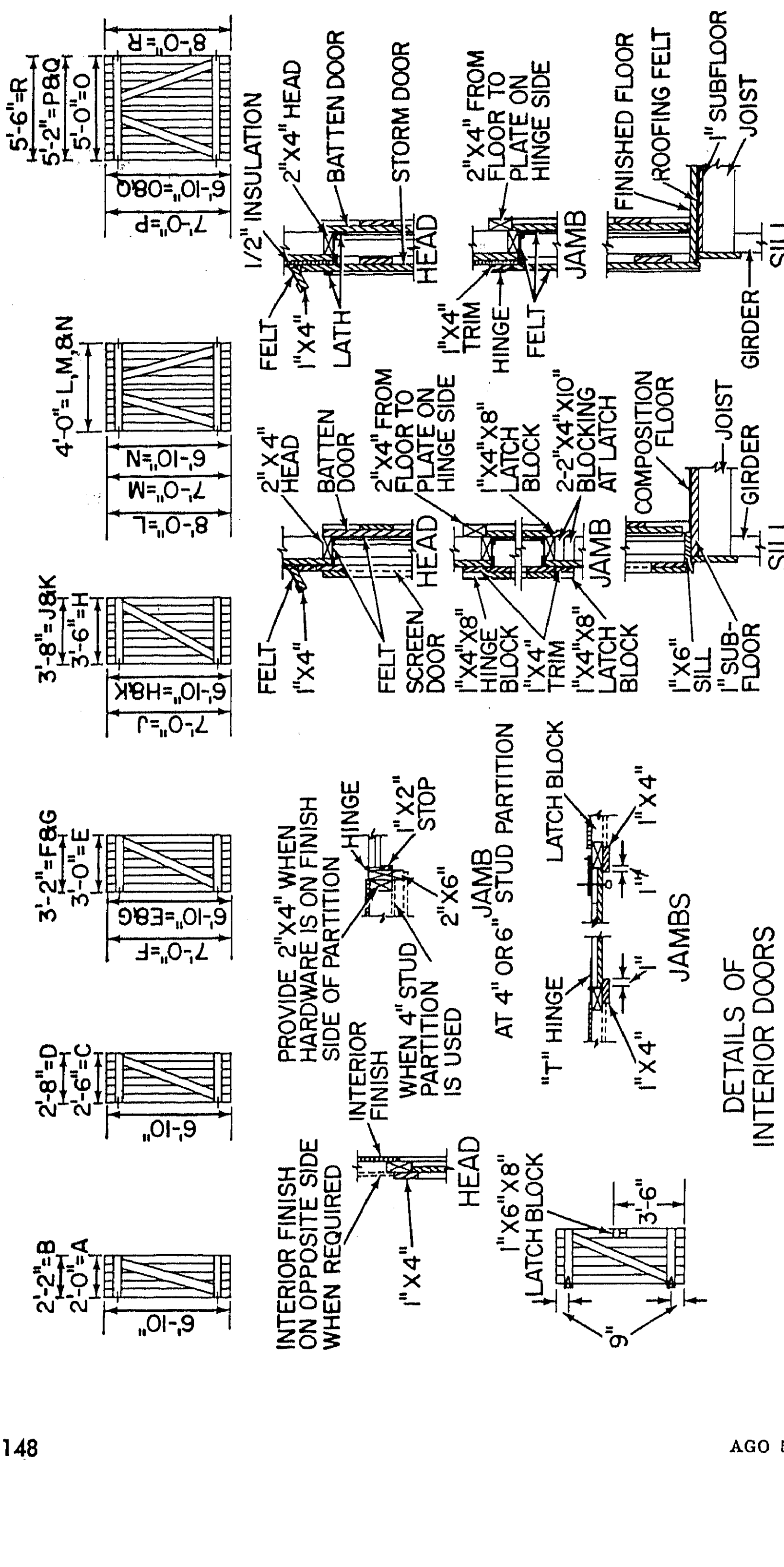


Figure 97. Details of interior doors.

panel arrangements, both horizontal, vertical, and combinations of both (fig. 98). A single-panel door has for its component parts a top rail, bottom rail, and two stiles which form the sides of the door. Panels of the horizontal type have intermediate rails forming the panels; and panels of the vertical type have horizontal rails and vertical stiles forming the panels. The rails and stiles of a door are mortised and tenoned, the mortise being cut in the side stiles. This construction is used for every rail joining the stiles. Vertical stiles in a vertical-panel door are tenoned into the horizontal rails, while the rails are tenoned into the side stiles. Top and bottom rails on paneled doors differ in width, the bottom rail being considerably wider. Intermediate rails are usually the same width as the top rail. Paneling material is usually plywood which is set in grooves or dadoes in the stiles and rails, with the molding attached on most doors as a finish.

(2) *Flush doors.* Flush doors are usually perfectly flat on both sides, but sometimes they are paneled on one side. Solid planks are rarely used for flush doors. Flush doors are made up with solid or hollow cores with two or more plies of veneer glued to the cores.

(*a*) *Solid-core doors.* Solid core doors are made of short pieces of wood glued together with the ends staggered very much like in brick laying. One or two (usually two) plies of veneer are glued to the core. The first, about 1/8 inch thick, is applied at right angles to the direction of the core, and the other, 1/8 inch or less, is glued with the grain vertical. Strips, 3/4 inch by door thickness and of the same species of wood used for the panel, are glued to the edges of the door on all sides.

(*b*) *Hollow-core doors.* Hollow-core doors have wooden grids or other honeycomb material for their cores, with solid wood edging strips on all sides. Faces of this type of door are usually 3-ply veneer instead of two single plies. The hollow-core door has a solid block on both sides for door knobs and to permit the mortising of locks. The honeycomb-core door is for interior use only.

b. Hanging Mill-Built Doors. If mill-built doors are used, install them in the finished door frames as described below.

(1) Cut off the stile extensions, if any, and place the door in the frame. Plane the edges of the stiles until the door fits tightly against the hinge side and clears the lock side of the jamb about 1/16 inch. Be certain the top fits squarely

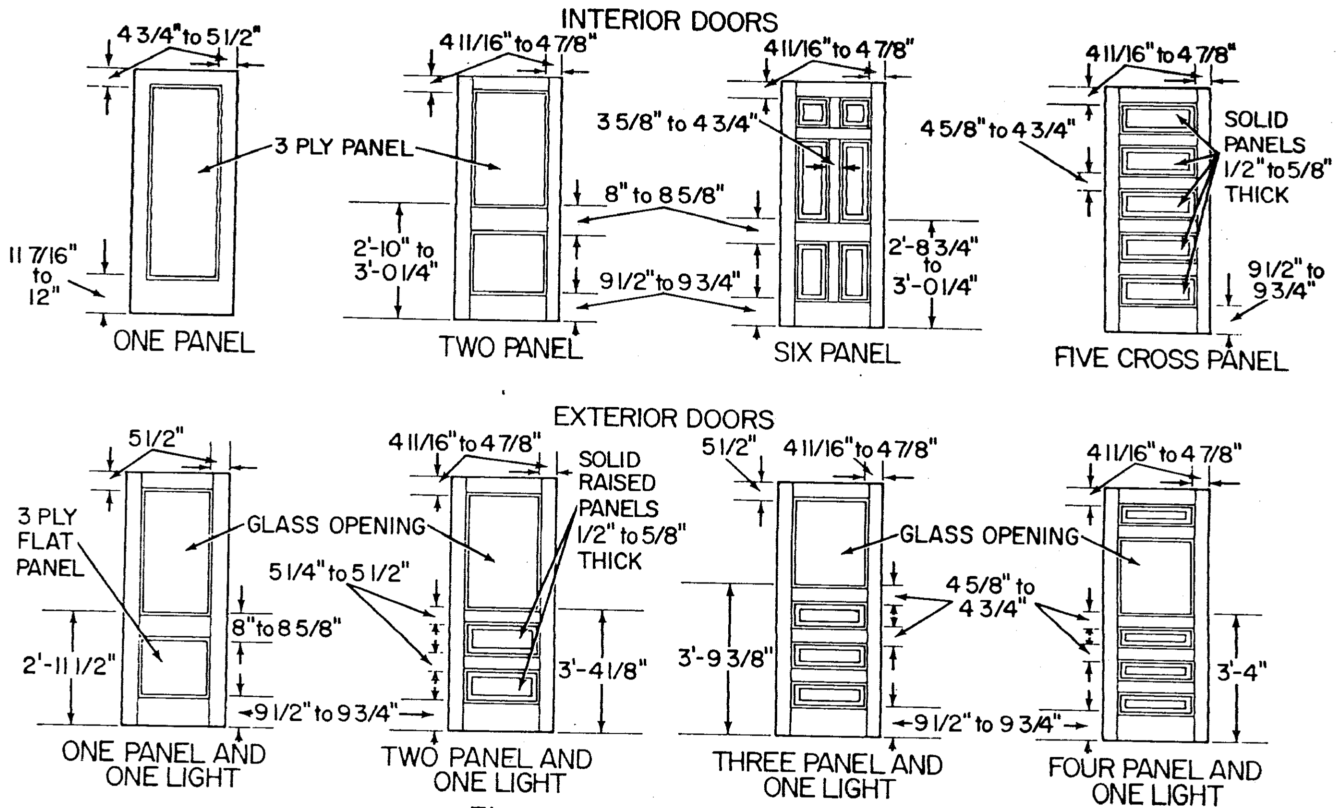


Figure 98. Types of mill-built doors.

into the rabbeted recess and that the bottom swings free of the finished floor about ½ inch. The lock stile of the door must be beveled slightly so that the edge of the stile will not strike the edge of the door jamb.

(2) After proper clearances have been made, tack the position in the frame and wedge at the bottom (fig. 99). Mark positions of hinges, with a sharp pointed knife, on the stile and on the jamb. The lower hinge must be placed slightly above the lower rail of the door and the upper hinge of the door must be placed slightly below the top rail of the door in order to avoid cutting out a portion of the tenons of the door rails which are housed in the stile. There are three measurements to be marked—the location of the butt on the jamb; the location of the butt on the door; and the thickness of the butt on both jamb and door.

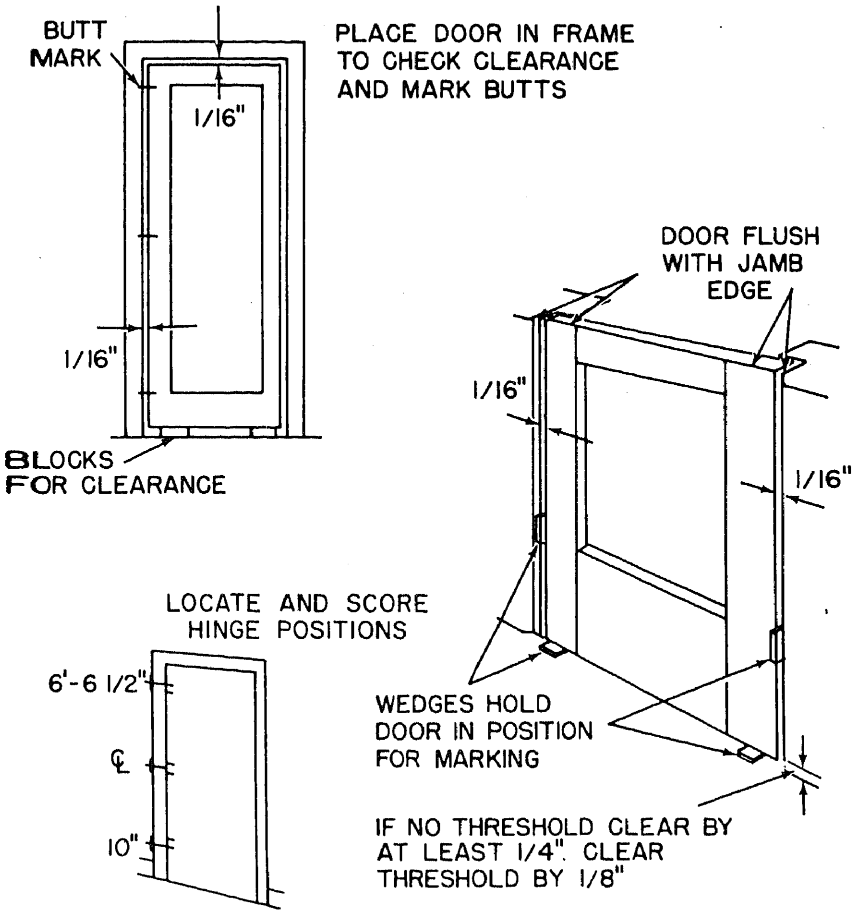


Figure 99. Wedging door, locating and scribing hinge positions.

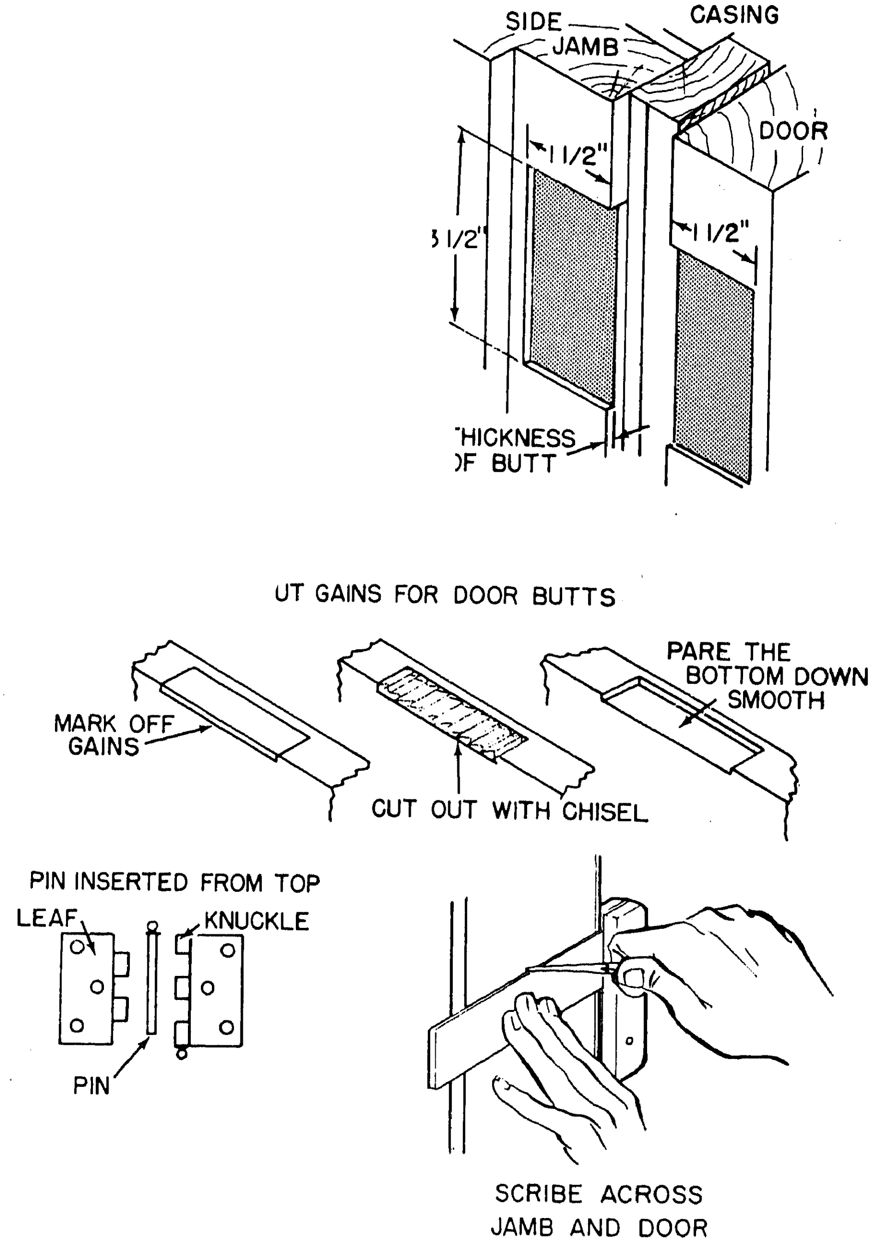


Figure 100. Installing door butts.

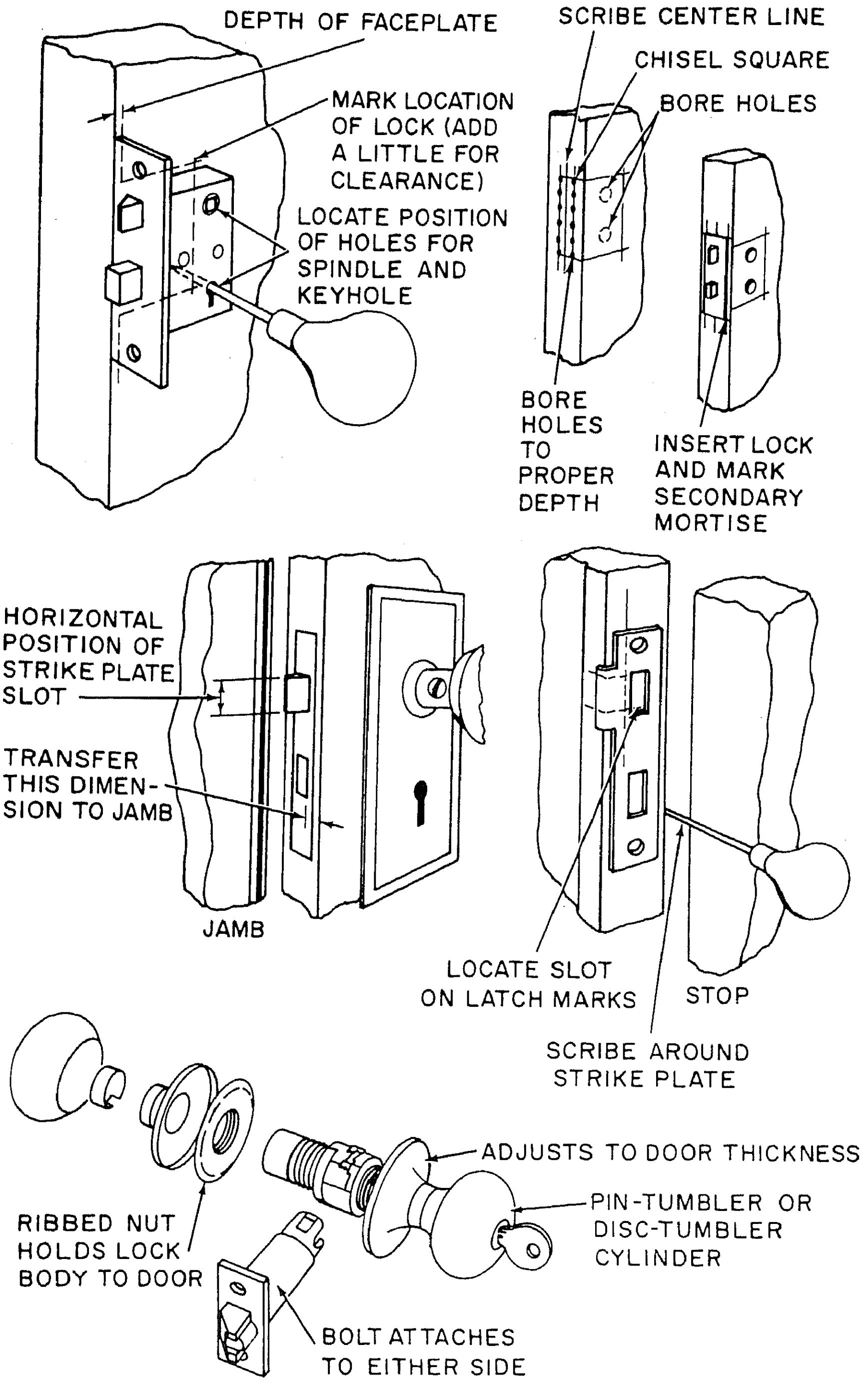


Figure 101. Installation of lock.

(3) Door butts or hinges are designed to be mortised into door and frame as shown in figure 100. Butt sizes indicate the height of each leaf and the width of the pair when open. Use three butt hinges on all full length doors, to prevent warping and sagging. Place butts and mortise them with the utmost accuracy so the door will open and close properly and so the door, when open, will not strike the casing. The butt pin must project more than half its thickness from the casing.

(4) Using the butt as a pattern, mark the dimensions of butts on the door edge and the face of the jamb.

(5) Cut the marked areas, called gains, on the door jambs and door to fit the butts. Use a 1-inch chisel and mallet.

(6) Test the gains. The butts must fit snugly and exactly flush with the edge of the door and the face of the jamb.

(7) Screw three halves of the butt joints on the door and the other three halves on the jamb. Place butts so pins are inserted from the top when the door is hung.

(8) Set the door against the frame so the two halves of the top butt engage. Insert the top pin. Engage and insert pins in bottom and center butts.

67. Lock Installation

(fig. 101)

After placing hinges in position, mark off position of lock on the lock stile. The lock is placed about 36 inches from the floor level. Hold the case of the mortise lock on the face of the lock stile and mark off with a sharp knife the area to remove from the edge of the stile to house the entire case. Mark off position of door knob hub and position of key. Mark off position of strike plate on the jamb. Bore out the wood to house the lock and strike chisel and mortises clean, and install the lock set.

Section II. WINDOW SASHES

68. Job-Built Sashes

a. Types. A window normally is composed of an upper and a lower sash. These sashes slide up and down, swing in or out, or may be stationary. There are two general types of wood sash—fixed or permanent; and movable. Fixed sashes are removable only with the aid of a carpenter. Movable sash may be of the variety that slides up and down in channels in the frame, called "double-hung"; or of the casement type that swings in or out and is hinged

at the side. Sliding sashes are counterbalanced by weights, called "sash weights"; their actual weight being equal to one-half that of each sash. Sashes are classified according to the number of lights—single or divided.

b. Construction (fig. 102). A sash can be made of 1- by 3-inch material with Cel-O-glass or an equivalent. Since Cel-O-glass does not break as easily as glass, careful handling in transporting is not required. Cel-O-glass is obtained in rolls, as screen wire or roll roofing, and can be cut to any desired size with a sharp-edged tool. Two frames are made with the glass substitute installed on one; the two frames are then nailed together. In making these frames, the side pieces are all cut the same length, the length being the height of the sash less the width of one piece of material. The top and bottom pieces are cut the same length as the window, less the width of the material. They are fastened at the joints with corrugated metal fasteners. When the two frames are nailed together, they should be turned so that the joints are not over each other. This staggers the joints and gives the sash more strength. If the sash is too large for the glass substitute to cover, a muntin may be placed in the sash to hold the glass substitute and should be fastened with corrugated metal fasteners. Where long sashes are made, a muntin should be placed in the center to give added strength.

c. Window Sash Installation.

(1) *Sliding windows.* Details of installation of windows are shown in figure 103.

(2) *Double-hung windows.* Place the upper sash in position and trim off a slight portion of the top rail of the sash to insure a good fit. Then tack the upper sash in position. Fit the lower sash in position by trimming off the stiles. Place the lower sash in the opening and trim off, from the bottom rail, a sufficient amount to permit the meeting rails (lower rail of upper sash and top rail of bottom sash) to meet on the level.

(3) *Sash weights.* If sash weights are used, remove each sash after it has been properly fitted and weigh each one. Select sash weights equal to half the weight of each sash and place in position in the weight pocket. Measure proper length of sash cord for lower sash and attach to the stile and weight on both sides. Adjust length of cord so that sash moves up and down easily and the weight does not strike the pulley or rest on the frame. Install the cords and weights for the upper sash and adjust the cord and weight so that each cord and weight runs

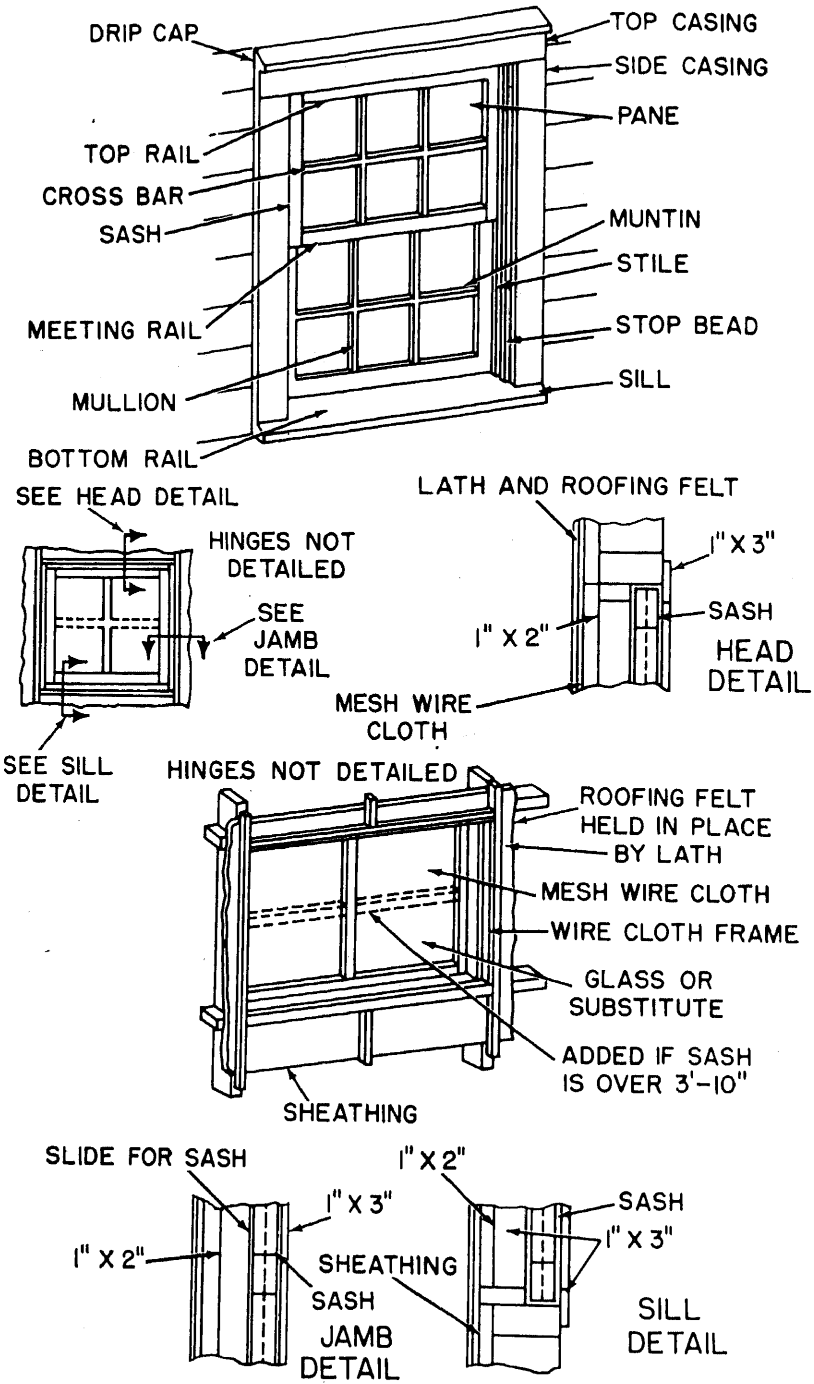
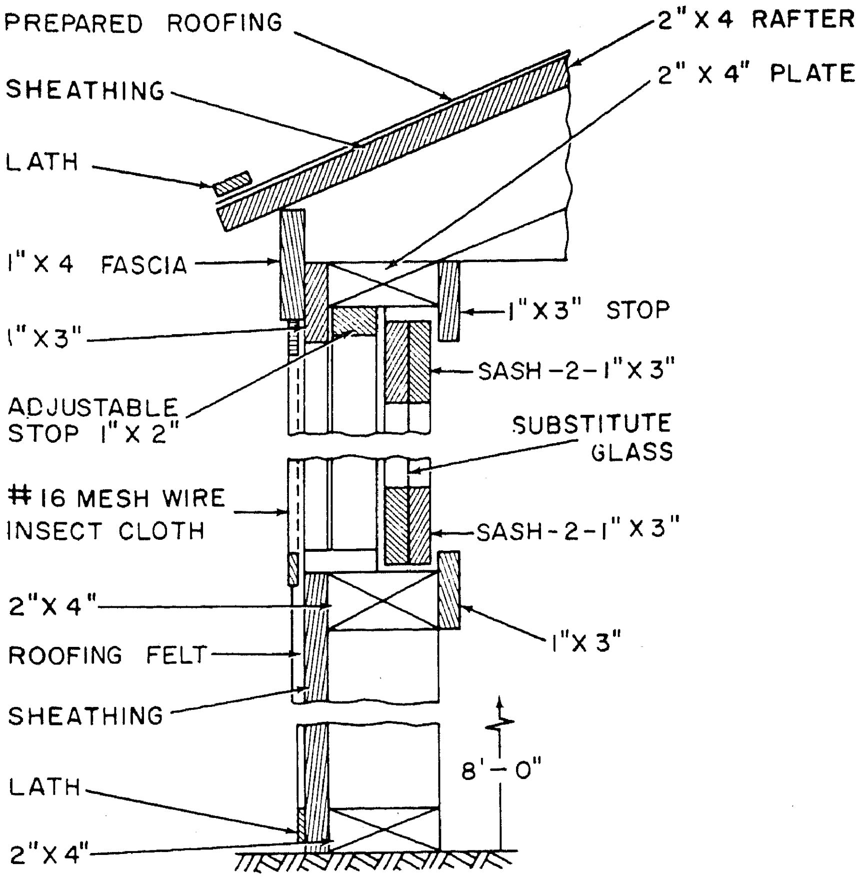
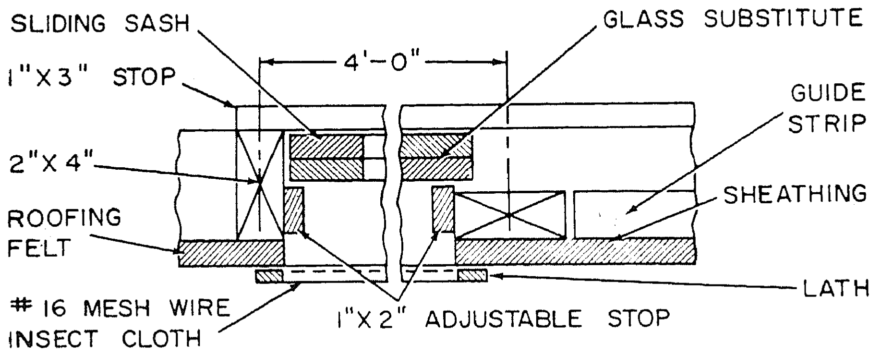


Figure 102. Window frame and sash detail.



TYPICAL SIDE WALL SECTION



SLIDING WINDOW

Figure 103. Window sash installation.

smoothly. Close the pockets in the frame and install the blind stop, parting stop, and bead stop.

69. Mill-Built Sashes

a. Types (fig. 104). Sashes are mill built of wood or steel. They are made for fixed or movable emplacement and may be casement or double-hung as desired. The sash size is determined by the size of the glass (fig. 104). Overall dimensions are generally standard and made to fit standard construction frames. The thickness of sash is usually $1\frac{1}{8}$, $1\frac{3}{8}$, or $1\frac{3}{4}$ inches. The $1\frac{3}{8}$ inch sash generally is used in frame construction. In giving the size of a sash, the width of the glass is always given first, then the height, then the number of pieces of glass, or lights. Thus a sash might be spoken of as a 24 by 26 by 1 light. This means that the glass itself is 24 by 26 inches and that there is only one piece of glass. However, the sash would be larger than 24 by 26 inches because of the frame around the glass. For the frame of a two-light window with a $1\frac{3}{8}$-inch check rail, add 4 inches to the width and 6 inches to the length.

Example: A two-light window has a glass size of 24 by 26, meaning that the glass in each sash is 24 inches wide and 26 inches high. Find the size of the window frame.

Solution: 24 inches + 4 inches = 28 inches, or 2 feet 4 inches, the width. 26 inches $\times$ 2 = 52 inches, 52 inches + 6 inches = 58 inches, or 4 feet 10 inches, the length. Therefore, the window frame size for these sashes would be 2 feet 4 inches by 4 feet 10 inches.

b. Installation.

(1) Prepare the sash cords, chains, or balances that are to be used. If cords are used, tie them to the weights, run them through the pulleys at the top, and tie a knot in the end of each. This knot will be set in the side of the sash in a recess made to receive it.

(2) Adjust the length of the cord. The length of the cord can be determined by placing the sash in its position and measuring. When the inside sash is down in place, the weight for that sash should be near the top pulley. When the outside sash is up in place, the weight for it should be down, not quite touching the bottom.

(3) Fit the outside top sash first. Do not fit it too tightly; allow for swelling. Use a sharp plane for squaring.

(4) Remove the parting bead on one side of the frame to enable you to put the sash into place. This is the strip

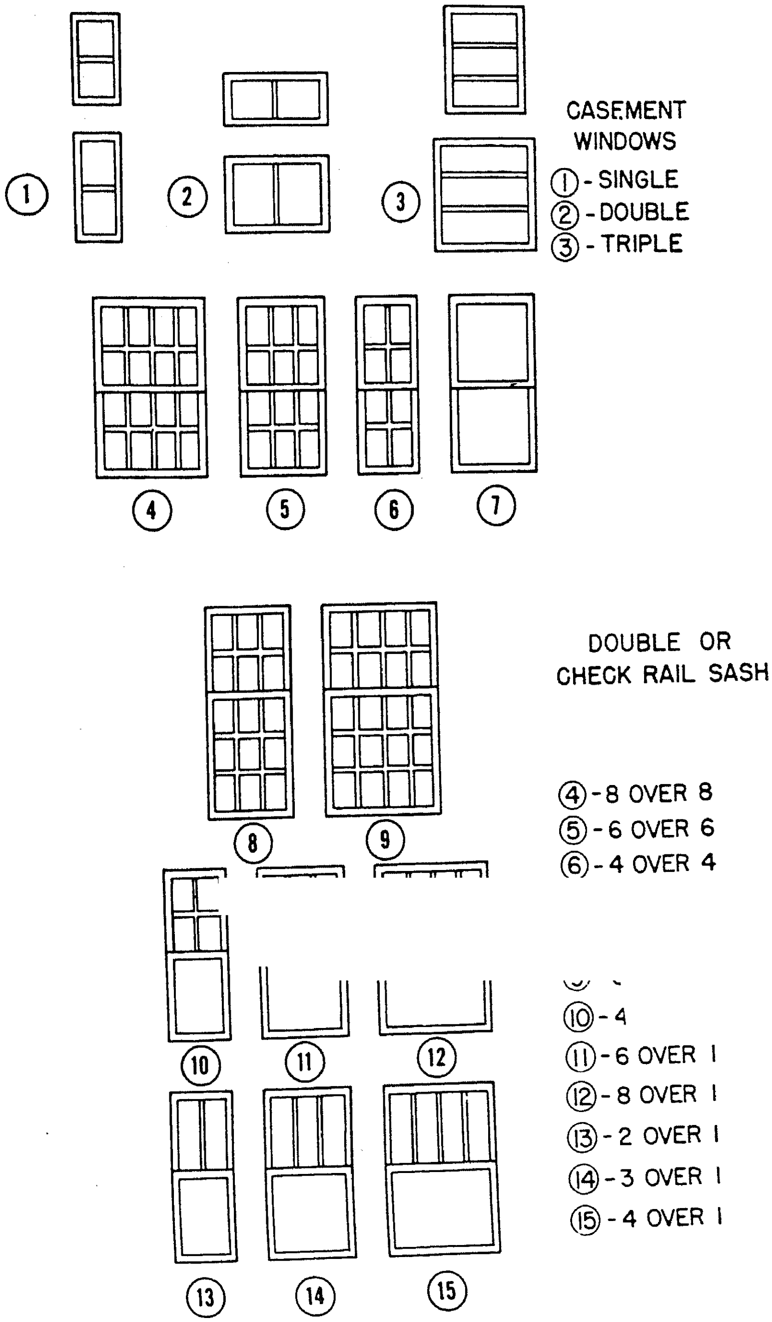


Figure 104. Types and sizes of milled sashes.

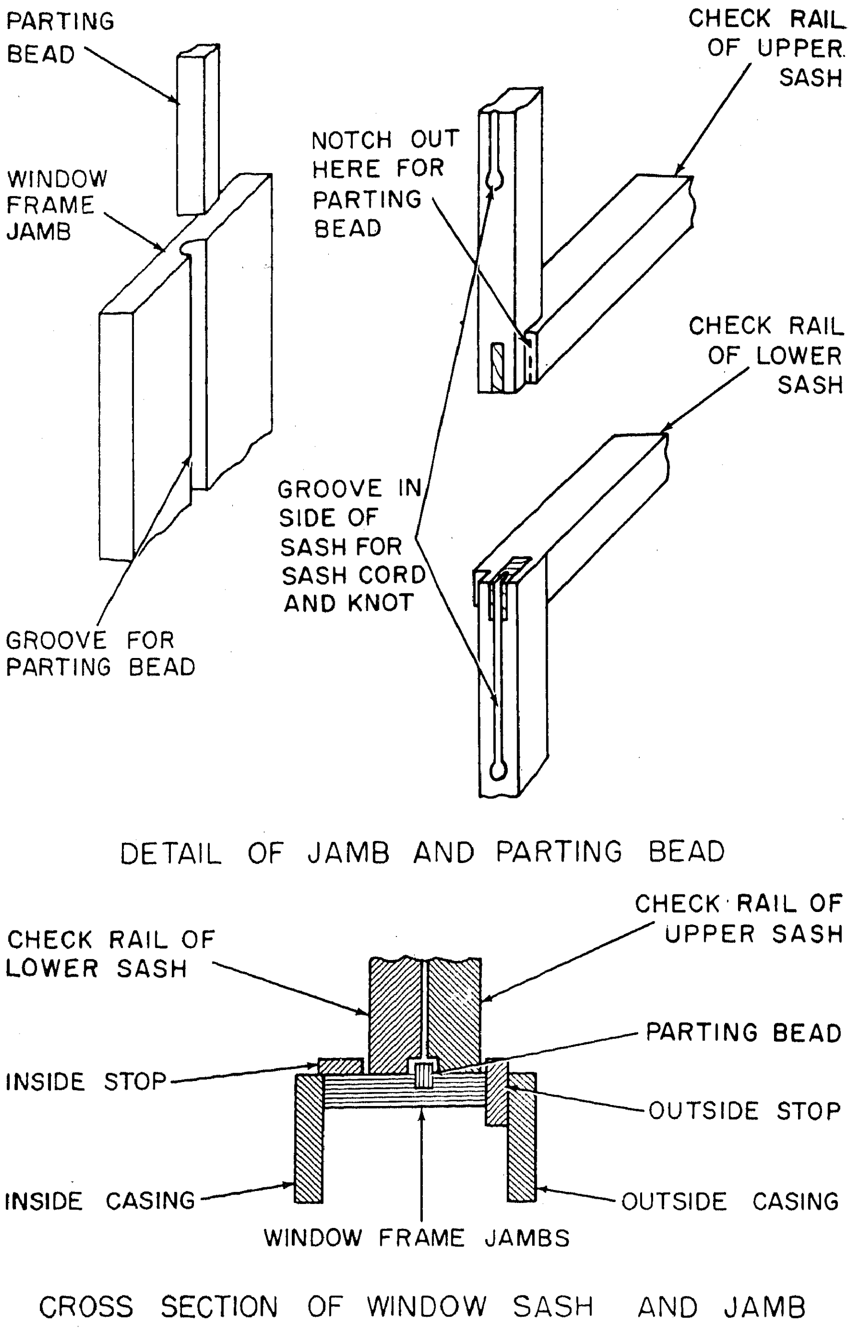


Figure 105. Details of check rails for double-hung window sash.

about $\frac{1}{2}$ by $\frac{3}{4}$ inch which is grooved into the frame on each side, separating the two sashes.

(5) Notch out each end of the check rail as far as the parting bead extends beyond the frame. This should be done accurately to prevent bad fitting, which in turn would either let in wind and cold or, if too tight, cause the sash to slide with difficulty (fig. 105).

(6) When the sash is fitted, put it in place, replace the parting beads, and attach sash cords to the sides.

(7) Plane and fit the inside bottom sash next for easy operation. Fit the sides of it first.

(8) After the sides have been fitted, set the sash in place and determine how much, if any, need come off the bottom, other than the bevel that is always planed on to match the slant of the window sill. The two check rails must come together and be even at the middle of the window. If not, the window locks will not meet or be workable.

(9) If the rails do not match, scribe off the necessary amount at the bottom, taking care to keep the same bevel on the bottom edge of the sash.

(10) When the lower sash is fitted, put it in place, secure the sash cords, and check both sashes for each operation.

Section III. SCREENS

70. Window Screens

Screen sash is usually $\frac{3}{4}$-inch stock, but for large windows and doors $1\frac{1}{8}$-inch material frequently is used or $\frac{3}{4}$-inch lumber is braced with a horizo

a. Construction (fig
or $2\frac{1}{4}$ inches wide. Scr
material. Cut screen about 1 inch wider and longer than the opening; cover the edges with molding; then rabbet the inside edges about $\frac{3}{8}$ by $\frac{1}{2}$ inch, attach the screen in the rabbet, and nail $\frac{3}{8}$ by $\frac{1}{2}$ inch molding flush with face of sash.

b. Joints. Window sashes may be made with open mortise, four tenons, with rails tenoned into stiles; with half-lap corners, or with butt joints or corrugated fasteners. In either of the first two cases, the joints may be nailed or glued.

c. Attaching Screen Material. When attaching screen material, start at one end and tack, or staple it with copper staples, holding the material tightly as you nail. Then, hand-stretch the screen along the side, working toward the other end and attach, making

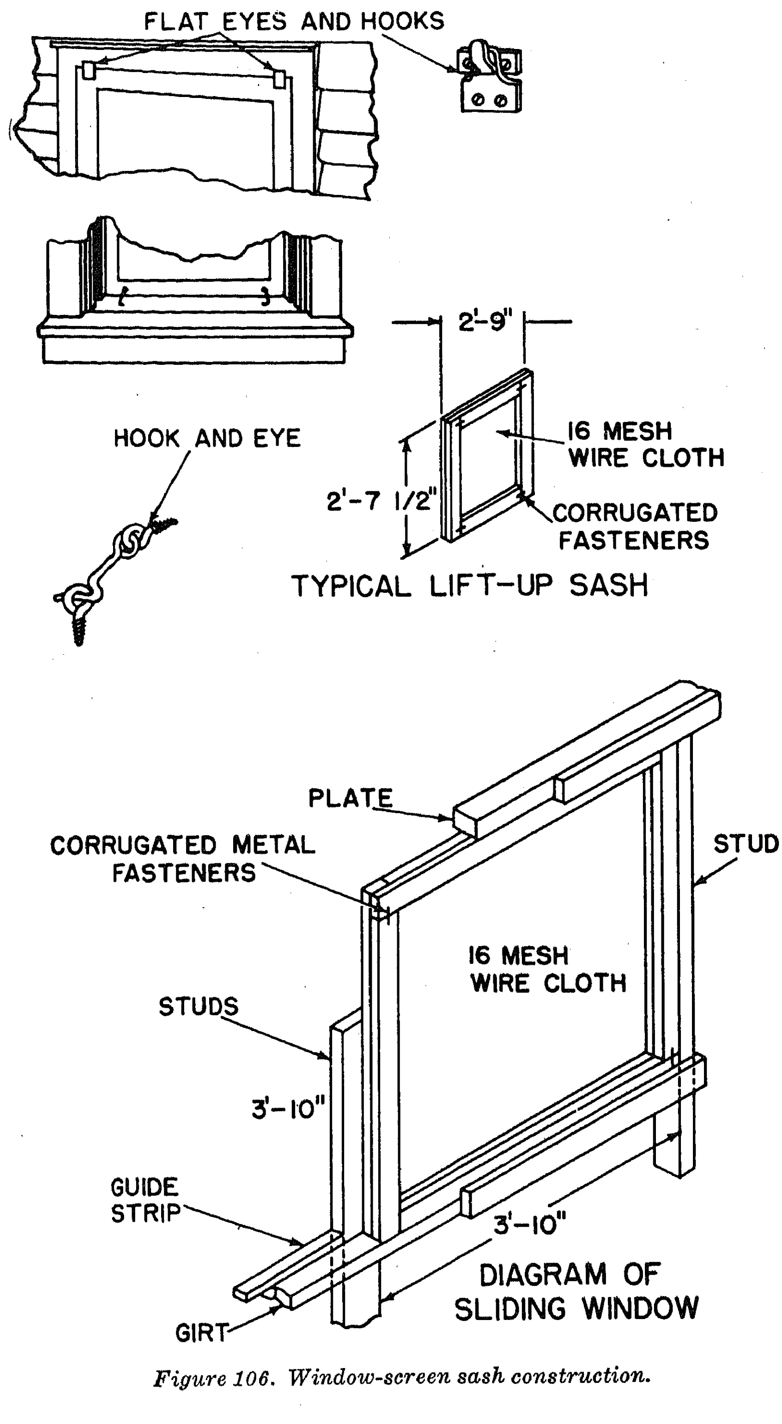


Figure 106. Window-screen sash construction.

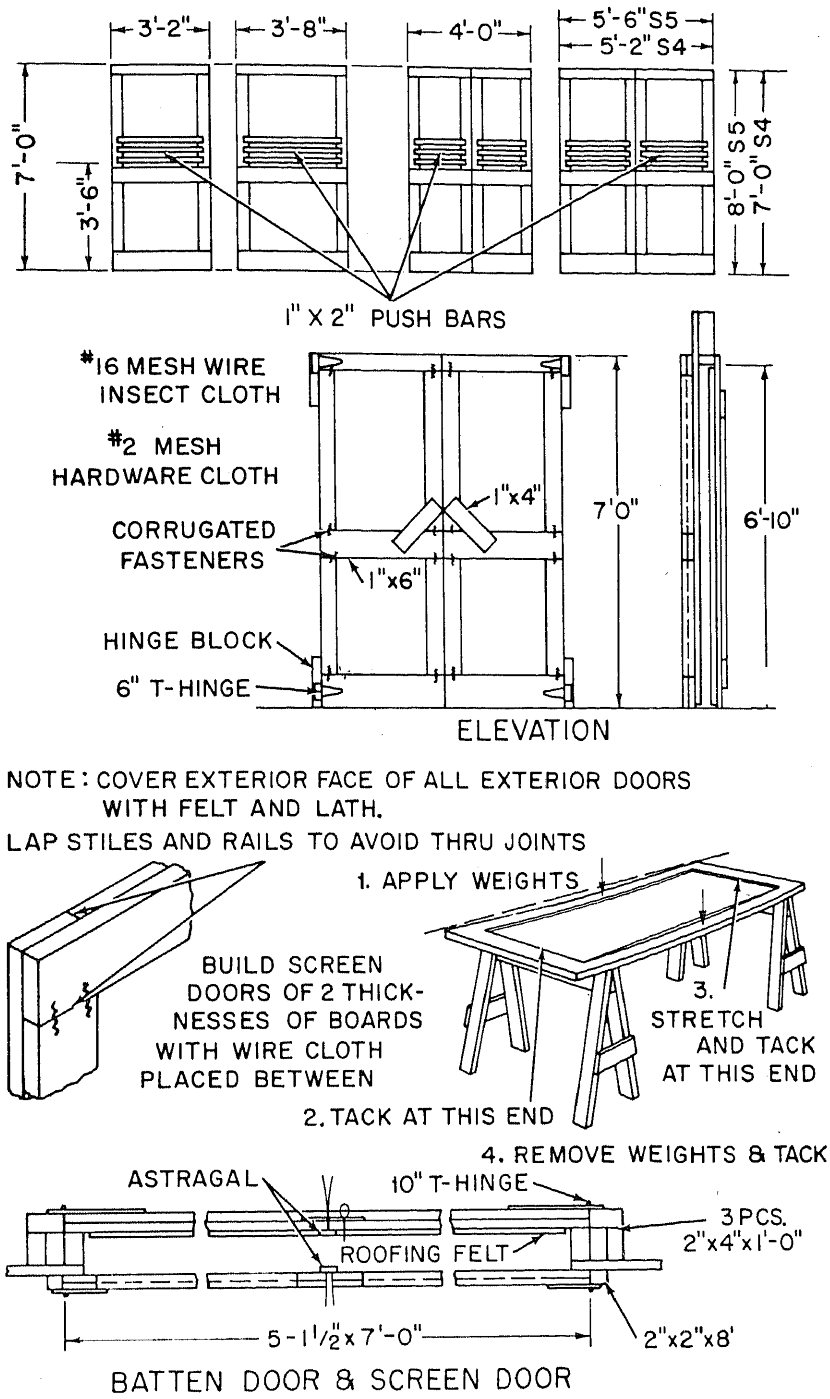


Figure 107. Door screen construction.

sure that the weave is parallel to the ends and sides. Tack the sides and apply the molding. Copper staples should be used for bronze or copper screen; cadmium staples should be used for aluminum screens.

71. Door Screens

Door screens are made as shown in figure 107. Two separate frames are made of 1 by 4 material for the sides and top and of 1 by 6 material for the bottom and middle pieces. The first frame is made of two side pieces the full length of the door; the cross-pieces are the width of the door less the width of the two side pieces. This frame is put together with corrugated metal fasteners, then the screen wire is applied. The second frame is made with the crosspiece the full width of the door. The side pieces are cut to correspond with the distance between the crosspieces. The second frame is placed over the first frame and nailed securely. For push-and-pull plates, two short braces of 1 by 4 are nailed to the side opposite the hinge side.

72. Hood or Canopy

The hood or canopy is used in tropical climates to afford protection to the screened opening at the ends of the buildings. They are framed to the end walls with short rafters which are nailed to the building with knee braces, as shown in figure 108. The rafters are nailed to the wall, the bottom edge flush with the bottom of the end plate. The rafters and braces are of 2 by 4's nailed with 8- or 10-penny nails. The sheathing is of the same material as the roof sheathing and is covered with roll roofing. The hood should extend about 2½ or 3 feet from the building.

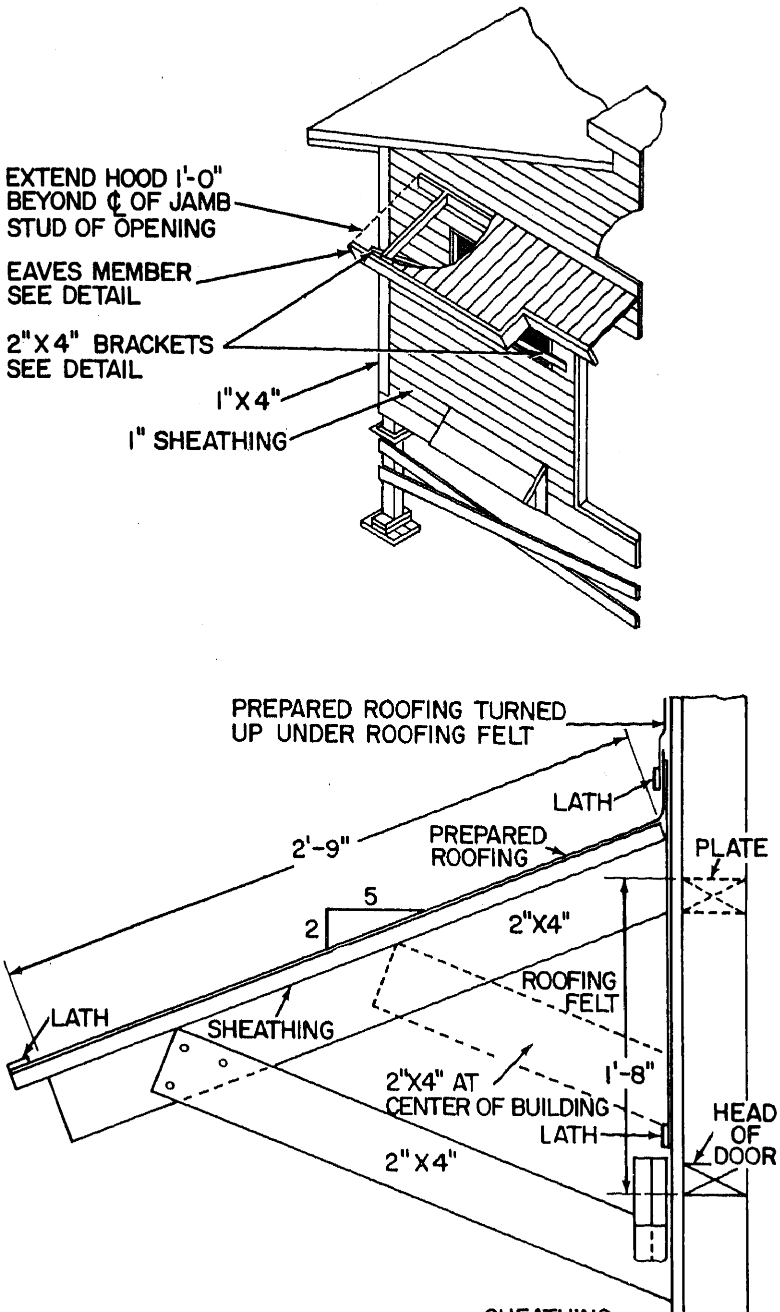


Figure 108. Hood or canopy.

CHAPTER 8

METHODS OF FRAME CONSTRUCTION

Section I. GENERAL

73. Methods

The method of erecting buildings directly affects the quantities of time, labor, and material required. Different methods are used for different types of buildings and under different conditions of climate and terrain. These methods may be divided into two types.

a. Single Piece Method. This is the method whereby each piece is separately erected in its proper place.

b. Perfabricated Section Method. This is the method whereby a complete section is built up as a unit and then set in the structure in the proper place. This method is used extensively because it makes for greater speed, better control over working parties, use of more manpower, and use of a standard list of sizes for each similar section. The use of plans as shown in TM 5–302, simplifies construction in this field.

74. Factors Considered in Selection of Method To Be Used

Engineer planning prior to erection operations will provide an orderly and definite series of operations to prevent confusion, duplication of effort, and waste of material. Factors to be considered in determining the erection method to be used and in planning for the erection operation are construction plant layout, distribution of material, number of skilled and semiskilled personnel available for the operation, and number and type of units to be constructed. A list should be compiled of the various separate operations which comprise the erection procedure and an estimate made of the total number of man-hours required by each operation, in terms of the overall project. This estimate will form the basis for determining the number and type of personnel needed and for organizing the erection crew or crews. Arrangements for assembling the necessary materials at the job site and for performing preliminary cutting and assembly should be made well in advance.

Section II. PROCEDURES IN SINGLE PIECE METHOD

75. Division of Work and Assignment of Tasks

When applying the single piece method to a building progra
the officer in charge of the construction divides the men into wo
ing parties, the size of a party varying according to the work
be done. The duties may be divided among the parties as follov

a. Laying out for the foundation.

b. Grading and excavation.

c. Laying out and cutting various sizes of

d. Carrying material to the cutting and ere

76. Assignment of New Tasks

If a party completes its tas
it is assigned a new task. For
foundation completes its work
begun, it is assigned a new du
other task that is to be done. The erecting p
ground and continues until the roof has been c
built in the following order: footings, piers, sill
studs, plates, girts, rafters, bracing, siding, sheathing,
doors, windows, steps, and inside finish (if used).

Section III. PROCEDURES, PREFABRICATED SECTION METHOD

77. Preparation for Application of Prefabricated Section Method

This method of construction, also known as the preassembly method, requires careful planning and preparation prior to actual erection of a structure. Most army buildings are now erected by this method. The general procedure is as follows:

a. Before measurement and cutting of the lumber, the number and size of like sections should be determined from the blueprint. This is to insure planning for the correct numbers of each piece. The carpenter secures the information needed from the blueprints and assigns a crew of men to cut and assemble one section. In most cases, a template is made to be used as a guide for assembling the section. The template should be built square, correct in size, and level to insure that the section is of the correct size when assembled in the template.

b. The number and size of each piece of timber that is to be used in a section is taken from the blueprint and given to the man in charge of the cutting party. The cutting party cuts the timber to

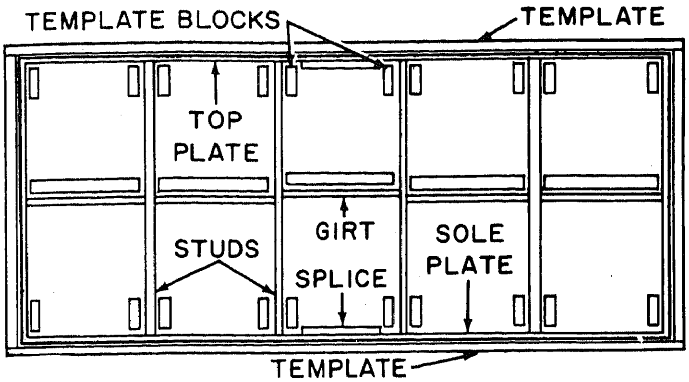


Figure 109. Template for framing walls.

the correct length by the use of the handsaw or power saws. The length is measured by the use of square and tape. After one piece has been cut to the correct size, it may be used as a pattern for marking the remaining pieces. The pattern is set up by nailing two blocks to the piece of correct size, one near each end, as shown in figure 113. These blocks act as stops to hold the pattern in place on the timber to be marked. Several cutting and assembling parties may be used at one time on different types of sections.

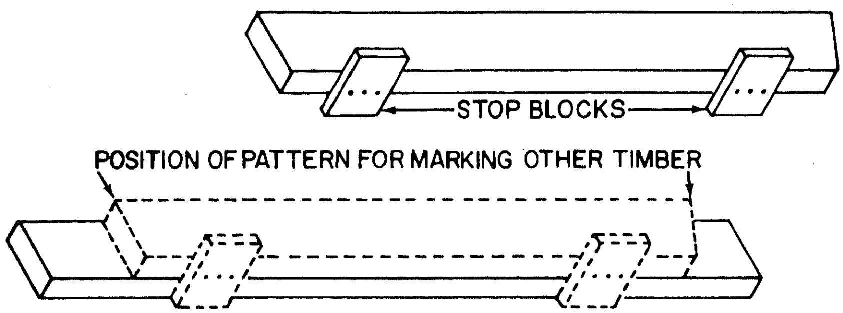


Figure 101. Marking pattern.

78. Assembly of Sections

A party is used to assemble the sections, which is very simple when templates are used. The plate and sole are placed in the template with the studs and girts between; then the door and window posts, if any, are placed (fig. 109). The girts, sole, and plate are nailed to the studs with 16- or 20-penny nails. If insulation board is used, it and the wall sheathing are applied to the section before it is taken out of the template. By applying the wall finish before raising the section, time is saved since no scaffold or ladders need be used.

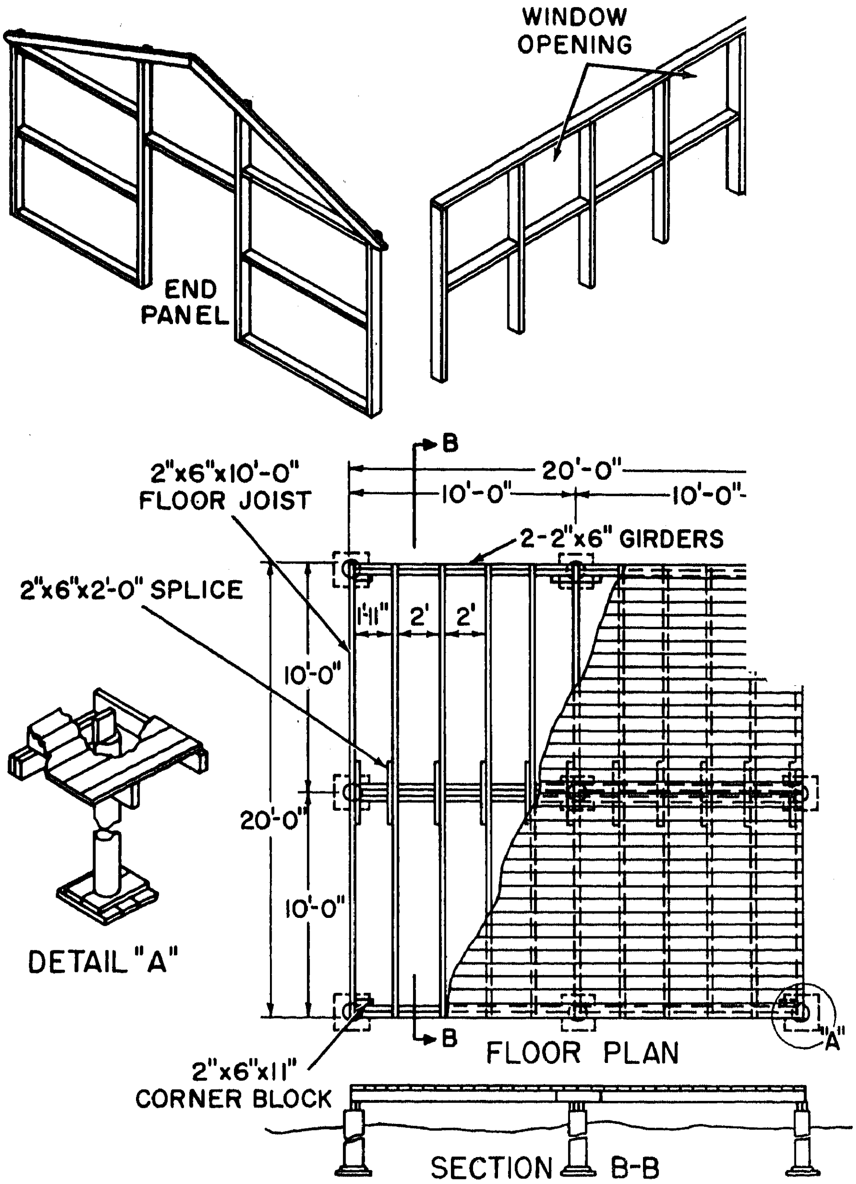


Figure 111. Erecting sections.

The method described above does not apply to floors and roofs, because they seldom are assembled in sections. Rafters may be assembled as described in paragraph 49.

79. Erection of Sections

Assembled sections are erected by an erecting party. This party sets the sections into place, braces them temporarily, and nails them together. The end section should be the first section erected, and it may be erected on graded earth. The sidewall sections are next erected and should be so erected as to keep the two walls even. The rafter party can then place the rafters on the walls. The carpenter should know how to divide the construction into arts so as to use the maximum number of men with the minimum of time. Parties should be set up as follows: layout party, ng party, assembling party, carrying party, erection party for walls, erecting party for rafters, sheathing party, roofing rty, and door-and-window party.

80. Scope of Prefabricated Section Method

The preassembly method of erection may be used for all types of small buildings and large warehouses. When this method is used for the latter, cranes or gin poles are used to place sections too heavy to be handled by hand. Where machinery is used to erect sections, caution should be observed in fastening the cable or rope to avoid damaging the section.

APPENDIX I

REFERENCES

1. Publication Indexes

DA Pam 108–1	Index of Army Motion Pictures, Film-strips, Slides, and Phono-Recordings.
DA Pam 310-series	Military Publications Indexes, (as applicable).

2. Field Manuals

FM 21–5	Military Training.
FM 21–6	Techniques of Military Instruction.
FM 21–30	Military Symbols.

3. Dictionaries of Terms and Abbreviations

AR 320–5	Dictionary of United States Arm-
DA Pam 320–1	Dictionary of United States Terms for Joint Usage.
AR 320–50	Authorized Abbreviations and Brevity Codes.

4. Technical Manuals

TM 5–232	Elements of Surveying.
TM 5–302	Construction in the Theater of Operations.
TM 5–461	Engineer Hand Tools.
TM 5–541	Control of Soils in Military Construction.
TM 5–613	Woodworking and Furniture Repair: Repairs and Utilities.
TM 5–704	Construction Print Reading in the Field.
TM 5–742	Concrete and Masonry.

5. U. S. Government Printing Office Handbooks

American lumber standards for softwood lumber, recorded voluntary recommendations of the trade (1954).

APPENDIX II

ABBREVIATIONS AND SYMBOLS

1. Abbreviations

The following abbreviations in connection with lumber are used by the carpenter:

AD__________air-dried
a.l.__________all length
av.__________average
av. w.________average width
av. l.________average length
bd.__________board
bd. ft.________board foot
bdl.__________bundle
bev.__________beveled
b.m.__________board (foot) measure
btr.__________better
clg.__________ceiling
clr.__________clear
CM__________center matched; that is, tongue-and-groove joints are made along the center of the edge of the piece.
Com.________common
Csg.__________casing
Ctg.__________crating
cu. ft.________cubic foot
D & CM______dressed (one or two sides) and center matched
D & M________dressed and matched; that is, dressed one or two sides and tongue and grooved on the edges. The match may be center or standard.
D. S.________drop siding.
D & SM______dressed (one or two sides) and standard matched
D 2S & CM__dressed two sides and center matched
D 2S & M____dressed two sides and (center of standard) matched
D 2S & SM__dressed two sides and standard matched
Dim.__________dimension
E.____________edge
FAS__________firsts and seconds, a combined grade of the two upper grades of hardwoods.
f. bk.________flat back
fcty.__________factory (lumber)
F. G.__________flat grain
Flg.__________flooring
f. o. k.________free of knots
Frm.__________framing
ft.____________foot or feet
Hdl.__________handle (stock)
Hdwd.________hardwood

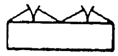
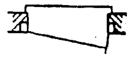
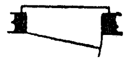
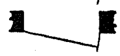
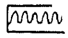
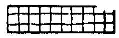
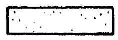
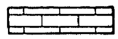
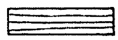
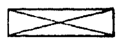
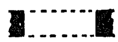
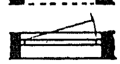
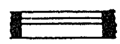
Hrt.________heart
Hrtwd.______heartwood
in.__________inch or inches
KD.________kiln-dried
k. d.________knocked down
lbr.________lumber
lgr.________longer
lgth.________length
lin. ft.______linear foot, that is, 12 inches
L. R.________log run
Lr. MCO____log run, mill culls out
M.__________thousand
M. b. m.______thousand (feet) board measure
MCO________mill culls out
Merch.______merchantable
M. R.________mill run
m. s. m.______thousand (feet) surface measure
m. w.________mixed width
No.__________number
1s & 2s______ones and twos, a combined graded of the hardwood grades of firsts and seconds.
Ord.________order
P.__________planed
Pat.________pattern
Pky.________picky
Pln.________plain, as in plain sawed
Pn.__________partition
Qtd.________quartered (with reference to hardwoods)
rd.__________round
rdm.________random
res.________resawed
rfg.________roofing
Rfrs.________roofers
rip.________ripped
r. l.________random length
r. w.________random width
S & E______surfaced one side and one edge
S2S & M____surfaced two sides and standard or center matched
S2S & SM___surfaced two sides and standard matched
Sap.________sapwood
S1E ________surfaced one edge
S1S1E______surfaced one side and one edge
S1S2E______surfaced one side and two edges
S2E________surfaced two edges
S4S ________surfaced four sides
S & CM______surfaced one or two sides and center matched
S & M______surfaced and matched; that is, surfaced one or two sides and tongued and grooved on the edges. The match may be center or standard.
S & SM ______surfaced one or two sides and standard matched
S2S & CM___surfaced two sides and center matched
Sap.________sapwood
SB ________standard bead
Sd.__________seasoned
Sdg.________siding

Sel.________select
S. E. Sd.____square-edge siding
s. f.________surface foot; that is, and area of 1 square foot
Stfwd.______softwood
Sh. D.______shipping dry
Ship_______shiplap
Sm.________standard matched
m.________surface measure
n. d.______sap no defect
________sound
________square
.______square edge
. & S.___square edge and sound
_______squares
_______standard
_______stock
_______sound wormy
______tongued and grooved
S_____top, bottom, and sides
_______timbers
________vertical grain
. l.______wider, all length
var.________wider
wt.________weight
wth.________width

2. Symbols

Symbols commonly used in carpentry are given below. For additional information on the various symbols used in construction plans and blueprints, refer to TM 5–704.

a. Architectural symbols.

Tile	
Earth	
Plaster	
Sheet metal	
Built-in cabinet	
Outside door: Brick wall	
Frame wall	
Inside door: Frame wall	
Brick	
Firebrick	
Concrete	
Cast concrete block	
Insulation: Loose fill	
Board or quilts	
Cut stone	
Ashlar	
Shingles (siding)	
Wood, rough	
Wood, finished	
Cased or arched openings	
Single casement window	
Double-hung windows	
Double casement window	

b. Plumbing.

Bath tubs:
- Corner
- Free standing

Floor drain

Shower drain

Hot-water tank — H.W.T.

Grease trap

Hose bibb or sill cock

Lavatories:
- Pedestal
- Wall-hung
- Corner

Toilets:
- Tank
- Flush valve

Urinals:
- Stall-type
- Wall-hung

Laundry trays

Built-in shower

Shower

Sinks:
- Single drain board.
- Double drain board.

c. Electrical Symbols.

Pull switch — P.S.

Single-pole switch — S_1

Double-pole switch — S_2

Triple-pole switch — S_3

Buzzer

Floor outlet

Bell

Drop cord

Ceiling outlet

Wall bracket

Single convenience outlet

Double convenience outlet

Ceiling outlet, gas & electric

Motor

Light outlet with wiring and switches indicated

APPENDIX III
PAINTS

The following table lists the various applications generally required for paint in building construction, gives a recommended formula for each, and shows the square footage one gallon of each type will cover under normal application:

Application	White lead (lb)	Linseed oil (gal)	Turpentine (gal)	Liquid drier (pt)	Mixing oil (gal)	Varnish (gal)	Gal paint produced	Sq ft covered per gal (1 coat)
Exterior wood:								
Back priming	100	3¼	------	1	------	------	6⅝	600
Prime coat	100	4	2	1	------	------	9⅜	600
Second coat	100	1½	1½	1	------	------	6⅜	700
Third coat	100	3¼	------	1	------	------	6⅝	700
First coat (repainting)	100	2	2	1	------	------	7⅜	700
Prime coat (2-coat work)[1]	100	1½	½	1	------	¾	6⅛	500
Wood shingles:								
Prime coat	100	4	2	1	------	------	9⅜	200
Second coat	100	2	1	1	------	------	6⅜	400
Third coat, flat	100	------	------	------	3 to 4	------	6¼ to 7¼	600
Third coat, gloss	100	3¼	------	1	------	------	6⅝	600
First coat (repainting)	100	2½	1¼	1	------	------	7⅛	500
Prime coat (2-coat work)	100	2	------	------	2	------	7¼	200
Asbestos cement shingles:								
Prime coat	100	2½	------	------	2½	------	8¼	300
Second coat (and third coat, flat)	100	------	------	------	4 to 5	------	7¼ to 8¼	500 600 (as third coat)
Third coat, gloss	100	3¼	------	1	------	------	6⅝	600
Brick, stucco, concrete, and stone:								
Prime coat (common brick)	100	5	¾	1	------	------	9⅛	200
Second coat (common brick)	100	3	1	1	------	------	7⅜	400
Prime coat (face or de-aired brick)	100	4	¾	1	------	------	8⅛	300
Second coat (face or de-aired brick)	100	2½	1¼	1	------	------	7⅛	400

Prime coat (stucco, concrete, & stone)	100	2½			2½		8¼	200
Second coat (stucco, concrete, & stone)	100				3 to 4		6¼ to 7¼	400
Third coat, flat	100				4		7¼	500
Third coat, gloss	100	3¼		1			6⅝	500
Interior woodwork:								
Prime coat	100	3	2	1			8⅜	600
Prime coat (alt.)	100				4		7¼	600
Prime coat (alt.)	100	3	1¼	1		2	9⅝	600
Second coat	100				3 to 4		6¼ to 7¼	700
Second coat (alt.)	100		1½	½		¾	5½	700
Third coat, flat	100				3 to 4		6¼ to 7¼	800
Third coat, flat (alt.)	100		1¾	½		⅛	5⅛	800
Third coat, semi-gloss[2]	50				1½		6⅛	800
Third coat, semi-gloss (alt.)	100		1½	¼		1½	6¼	800
Interior plaster:								
Prime coat	100				4 to 5		7¼ to 8¼	600
Second coat (and third coat, flat)	100				3 to 4		6¼ to 7¼	800
Third coat, stipple	100				2		5¼	600
Third coat, sharp stipple	100	(add 1½ gals. flatting oil)					4¾	600
Third coat, semi-gloss	50	(add 3 gals. wall primer)			1½		6⅛	600
Third coat, plastic[3]	100			¼			5½	160

See notes at end of table.

Application	White lead (lb)	Linseed (gal)	ntine al)	Liquid drier (pt)	Mixing oil (gal)	Varnish (gal)	Gal paint produced	Sq ft covered per gal (1 coat)
Wood floors:								
Prime coat	100	3	2	1	----------	----------	8⅜	600
Second coat	100	½	2¼	½	----------	----------	6	700
Third coat	100	¾	¾	½	----------	1¼	6	700
Concrete floors:								
Prime coat	100	2½	----------	----------	2½	----------	8¼	200
Second coat	100	½	2¼	½	----------	----------	6	400
Third coat (use high-grade floor enamel).								
Exterior metal:								
Prime coat	[4]100	1⅞	1½	1½	----------	----------	4½	600
Second coat (dark)[5]	[4]100	1⅞	1½	1½	----------	----------	4⅝	600
Second coat (light)	100	1½	12 (pts)	1	----------	----------	6⅜	700
Third coat (dark)[6]	[4]25	3¼	3 (pts)	3	----------	----------	7	700
Third coat (light)	100	3¼	----------	1	----------	----------	6⅝	700

[1] Ad ¼ pint raw umber.
[2] Add 3 gallons wall primer.
[3] Add 1¼ gallons flatting oil and 22 pounds dry whiting.
[4] Red (not white) lead.
[5] Add ¾ pint lampblack.
[6] Add 1¾ pints lampblack and 5 pints Prussian blue.

APPENDIX IV
CONSTRUCTION RATES

Item
Building Layout (Using Line Leve''
Excavation (Hand-Rocky Soil) __
Foundation Units (Footers, Spre
Built-up-Girder (3–2" x 6"10')
Joists (2" x 6" x 10") ________
Bridging (Block) __________
Flooring _________________
Side Panels (includes install
End Panels (includes install
Roof Truss _______________
Sheathing (sides) _________
Sheathing (roof) ___________
Felt Siding (15# felt w/buttons)
Roofing (45#) __________________
Windows (including installation) _______________
Doors (5'–0" x 6'10" opening) ___________________
Steps (including Platform & Railing) ____________

Note. Rates are based on quantities taken from the Bill of Material __ ________ ____ tion plans as determined by units used in rates e.g. BF from Bill of Material; each from pl__

For the purpose of estimating labor requirements for buildings of the same type of construction a direct proportion based on square feet may be used. However, as the length of the new building deviates further from the comparative building the proportion breaks down due to end sections being a constant value. Therefore the following proportions have been used in comparing with the 20' x 100' building.

(1) 20' x 90' to 110' use direct proportion
(2) 20' x 60' to 90' add 5%
(3) 20' x 20' to 50' add 10%
(4) 20' x 120' to 130' subtract 5%

Additional variations will have to be made to compensate for difference in design and plumbing.

GLOSSARY

ır—Irons of special form used to fasten together timbers or ıonry.

ır bolts—Bolt which fastens columns, girders, or other mem- s to concrete or masonry.

ng—The bevel on the top edge of a hip rafter that allows the ing board to fit the top of the rafter without leaving a tri- ular space between it and the lower side of the roof covering.

n frame—The lightest and most economical form of con- ıction, in which the studding and corner posts are set up in tinuous lengths from first-floor line or sill to the roof plate.

ter—A small pillar or column used to support a rail.

trade—A series of balusters connected by a rail, generally d for porches, balconies, and the like.

—A low, flat molding.

-The bottom of a column; the finish of a room at the junc- ı of the walls and floor.

en (cleat)—A narrow strip of board used to fasten several pieces together.

tter board—A temporary framework used to assist in locating the corners when laying a foundation.

Beam—An inclusive term for joists, girders, rafters, and purlins.

Bedding—A filling of mortar, putty, or other substance in order to secure a firm bearing.

Belt course—A horizontal board across or around a building, usually made of a flat member and a molding.

Bevel board (pitch board)—A board used in framing a roof or stairway to lay out bevels.

Board—Lumber less than 2 inches thick.

Board foot—The equivalent of a board 1 foot square and 1 inch thick.

Boarding in—The process of nailing boards on the outside studding of a house.

Braces—Pieces fitted and firmly fastened to two others at any angle in order to strengthen the angle thus treated.

Bracket—A projecting support for a shelf or other structure.

Break joints—To arrange joints so that they do not come directly under or over the joints of adjoining pieces, as in shingling, siding, etc.

Bridging—Pieces fitted in pairs from the bottom of one floor joist to the top of adjacent joists, and crossed to distribute the floor load; sometimes pieces of width equal to the joists and fitted neatly between them.

Building paper—Cheap, thick paper, used to insulate a building before the siding or roofing is put on; sometimes placed between double floors.

Built-up timber—A timber made of several pieces fastened together, and forming one of larger dimension.

Carriages—The supports or the steps and risers of a flight of stairs.

Casement—A window in which the sash opens upon hinges.

Casing—The trimming around a door or window opening, either outside or inside, or the finished lumber around a post or beam, etc.

Ceiling—Narrow, matched boards; sheathing of the surfaces that inclose the upper side of a room.

Center-hung sash—A sash hung on its centers so that it swings on a horizontal axis.

Chamfer—A beveled surface cut upon the corner of a piece of wood.

Checks—Splits or cracks in a board, ordinarily caused by seasoning.

Clamp—A mechanical device used to hold two or more pieces together.

Clapboards—A special form of outside covering of a house; siding.

Columns—A support, square, rectangular, or cylindrical in section, for roofs, ceilings, etc., composed of base, shaft, and capital.

Combination frame—A combination of the principal features of the full and balloon frames.

Concrete—An artificial building material made by mixing cement and sand with gravel, broken stone, or other aggregate, and sufficient water to cause the cement to set and bind the entire mass.

Conductors—Pipes for conducting water from a roof to the ground or to a receptacle or drain; downspout.

Cornice—The molded projection which finishes the top of the wall of a building.

Counterflashings—Strips of metal used to prevent water from entering the top edge of the vertical side of a roof flashing; they also allow expansion and contraction without danger of breaking the flashing.

Deadening—Construction intended to prevent the passage of sound.

Drip—The projection of a window sill or water table to allow the water to drain clear of the side of the house below it.

Fascia—A flat member of a cornice or other finsh, generally the board of the cornice to which the gutter is fastened.

Flashing—The material used and the process of making watertight the roof intersections and other exposed places on the outside of the house.

Flue—The opening in a chimney through which smoke passes.

Flush—Adjacent surfaces even, or in some plane (with reference to two structural pieces).

Footing—An enlargement at the lower end of a wall, pier, or column, to distribute the load.

Footing form—A wooden or steel structure, placed around the footing that will hold the concrete to the deserved shape and size.

Foundation—That part of a building or wall which supports the superstructure.

Frame—The surrounding or inclosing woodwork of windows, doors, etc., and the timber skeleton of a building.

Framing—The rough timber structure of a building, including interior and exterior walls, floor, roof, and ceilings.

Full frame—The old fashioned mortised-and-tenoned frame, in which every joint was mortised and tenoned. Rarely used at the present time.

Furring—Narrow strips of board nailed upon the walls and ceilings to form a straight surface upon which to lay the laths or other finish.

Gable—The vertical triangular end of a building from the eaves to the apex of the roof.

Gage—A tool used by carpenters; to strike a line parallel to the edge of a board.

Gambrel—A symmetrical roof with two different pitches or slopes on each side.

Girder—A timber used to support wall beams or joists.

Girt (ribband)—The horizontal member of the walls of a full or combination frame house which supports the floor joists or is flush with the top of the joists.

Groove—A long hollow channel cut by a tool, into which a piece fits or in which it works. Two special types of grooves are the *dado*, a rectangular groove cut across the full width of a piece, and the *housing*, a groove cut at any angle with the grain and

part way across a piece. Dados are used in sliding doors, window frames, etc.; housings are used for framing stair risers and threads in a string.

Ground—A strip of wood assisting the plasterer straight wall and in giving a place to which the room may be nailed.

Header—A short joist supporting tail beams and fram trimmer joists; the piece of stud or finish over a lintel.

Headroom—The clear space between floor line and stairway.

Heel of a rafter—The end or foot that rests on the

Hip roof—A roof which slopes up toward the center fro necessitating a hip rafter at each corner.

Jack rafter—A short rafter framing between the wall p rafter.

Jamb—The side piece or post of an opening; sometimes the door frame.

Joint-butt—Squared ends or ends and edges adjoining e

Dovetail—Joint made by cutting pins the shape of do which fit between dovetails upon another piece.

Drawboard—A mortise-and-tenon joint with holes so bored that when a pin is driven through, the joint becomes tighter.

Fished—An end butt splice strengthened by pieces nailed on the sides.

Halved—A joint made by cutting half the wood away from each piece so as to bring the sides flush.

Housed—A joint in which a piece is grooved to receive the piece which is to form the other part of the joint.

Glue—A joint held together with glue.

Lap—A joint of two pieces lapping over each other.

Mortised—A joint made by cutting a hole or mortise, in one piece, and a tenon, or piece to fit the hole, upon the other.

Rub—A flue joint made by carefully fitting the edges together, spreading glue between them, and rubbing the pieces back and forth until the pieces are well rubbed together.

Scarfed—A timber spliced by cutting various shapes of shoulders, or jogs, which fit each other.

Joists—Timbers supporting the floor boards.

Kerf—The cut made by a saw.

Knee brace—A corner brace, fastened at an angle from wall stud to rafter, stiffening a wood or steel frame to prevent angular movement.

Laths—Narrow strips to support plastering.

Lattice—Crossed wood, iron plate, or bars.

Ledgerboard—The support for the second-floor joists of a balloon-frame house, or for similar uses; ribband.

Level—A term describing the position of a line or plane when parallel to the surface of still water, an instrument or tool used in testing for horizontal and vertical surfaces, and in determining differences of elevation.

Lintel (header)—The piece of construction or finish, stone, wood, or metal, which is over an opening; a header.

Lookout—The end of a rafter, or the construction which projects beyond the sides of a house to support the eaves; also the projecting timbers at the gables which support the verge boards.

Louver—A kind of window, generally in peaks of gables and the tops of towers, provided with horizontal slots which exclude rain and snow and allow ventilation.

Lumber—Sawed parts of a log such as boards, planks, scantling, and timber.

Matching, or tonguing and grooving—The method used in cutting the edges of a board to make a tongue on one edge and a groove on the other.

Meeting rail—The bottom rail of the upper sash of a double-hung window. Sometimes called the check rail.

Member—A single piece in structure, complete in itself.

Miter—The joint formed by two abutting pieces meeting at an angle.

Molding Base—The molding on the top of a base board.

Bed—A molding used to cover the joint between the plancier and frieze; also used as a base molding upon heavy work, and sometimes as a member of a cornice.

Lip—A molding with a lip which overlaps the piece against which the back of the molding rests.

Rake—The cornice upon the gable edge of a pitch roof, the members of which are made to fit those of the molding of the horizontal eaves.

Picture—A molding shaped to form a support for picture hooks, often placed at some distance from the ceiling upon the wall to form the lower edge of the frieze.

Mortise—The hole which is to receive a tenon, or any hole cut into or through a piece by a chisel; generally of rectangular shape.

Mullion—The construction between the openings of a window frame to accommodate two or more windows.

Muntin—The vertical member between two panels of the same piece of panel work. The vertical sash-bars separating the different panels of glass.

Newel—The principal post of the foot of a staircase; also the central support of a winding flight of stairs.

Nosing—The part of a stair tread which projects over the riser, or any similar projection; a term applied to the rounded edge of a board.

Piers—Masonry supports, set independently of the main foundation.

Pilaster—A portion of a square column, usually set within or against a wall.

Piles—Long posts driven into the soil in swampy locations or whenever it is difficult to secure a firm foundation, upon which the footing course of masonry or other timbers are laid.

Pitch—Inclination or slope, as for roofs or stairs, or the rise divided by the span.

Pitch board—A board sawed to the exact shape formed by ᴛɪ tread, riser, and slope of the stairs and used to lay o carriage and stringers.

Plan—A horizontal geometrical section of a building, showing the walls, doors, windows, stairs, chimneys, columns, etc.

Planks or lumber—Material 2 or 3 inches thick and more than 4 inches wide, such as joists, flooring, etc.

Plaster—A mixture of lime, hair, and sand, or of lime, cement, and sand, used to cover outside and inside wall surfaces.

Plate—The top horizontal piece of the walls of a frame building upon which the roof rests.

Plate cut—The cut in a rafter which rests upon the plate; sometimes called the seat cut.

Plumb cut—Any cut made in a vertical plane; the vertical cut at the top end of a rafter.

Ply—A term used to denote a layer or thickness of building or roofing paper as two-ply, three-ply, etc.

Porch—An ornamental entrance way.

Post—A timber set on end to support a wall, girder, or other member of the structure.

Plow—To cut a groove running in the same direction as the grain of the wood.

Pulley stile—The member of a window frame which contains the pulleys and between which the edges of the sash slide.

Purlin—A timber supporting several rafters at one or more points, or the roof sheeting directly.

Rabbet or rebate—A corner cut out of an edge of a piece of wood.

Rafters, common—Those which run square with the plate and extend to the ridge.

Cripple—Those which cut between valley and hip rafters.

Hip—Those extending from the outside angle of the plates toward the apex of the roof.

Jacks—Those square with the plate and intersecting the hip rafter.

Valley—Those extending from an inside angle of the plates toward the ridge or center line of the house.

Rail—The horizontal members of a balustrade or panel work.

Rake—The trim of a building extending in an oblique line, as rake dado or molding.

Return—The continuation of a molding or finish of any kind in a different direction.

Ribband—(See Ledgerboard.)

Ridge—The top edge or corner formed by the intersection of two roof surfaces.

Ridge cut—(See Plumb cut.)

Rise—The vertical distance through which anything rises, as the rise of a roof or stair.

Riser—The vertical board between two treads of a flight of stairs.

Roofing—The material put on a roof to make it wind and waterproof.

Rubble—Roughly broken quarry stone.

Rubble masonry—Uncut stone, used for rough work, foundations, backing, and the like.

Run—The length of the horizontal projection of a piece such as a rafter when in position.

Saddle board—The finish of the ridge of a pitch-roof house. Sometimes called comb board.

Sash—The framework which holds the glass in a window.

Sawing, plain—Lumber sawed regardless of the grain, the log simply squared and sawed to the desired thickness; sometimes called slash or bastard sawed.

Scab—A short piece of lumber used to splice, or to prevent movement of two other pieces.

Scaffold or staging—A temporary structure or platform enabling workmen to reach high places.

Scale—A short measurement used as a proportionate part of a larger dimension. The scale of a drawing is expressed as ¼ inch = 1 foot.

Scantling—Lumber with a cross-section ranging from 2 by 4 inches to 4 by 4 inches.

Scarfing—A joint between two pieces of wood which allows them to be spliced lengthwise.

Scotia—A hollow molding used as a part of a cornice, and often under the nosing of a stair tread.

Scribing—The marking of a piece of wood to provide for the fitting of one of its surfaces to the irregular surface of another.

Seat cut or plate cut—The cut at the bottom end of a rafter to allow it to fit upon the plate.

Seat of a rafter—The horizontal cut upon the bottom end of a rafter which rests upon the top of the plate.

Section—A drawing showing the kind, arrangement, and proportions of the various parts of a structure. It is assumed that the structure is cut by a plane, and the section is the view gained by looking in one direction.

Shakes—Imperfections in timber caused during the growth of the tree by high winds or imperfect conditions of growth.

Sheathing—Wall boards, roofing boards; generally applied to row boards laid with a space between them, according tc length of a shingle exposed to weather.

Sheathing paper—The paper used under siding or shingles to insulate in the house; building papers.

Siding—The outside finish between the casings.

Sills—The horizontal timbers of a house which either rest upon the masonry foundations or, in the absence of such, form the foundations.

Sizing—Working material to the desired size; a coating of glue, shellac, or other substance applied to a surface to prepare it for painting or other method of finish.

Sleeper—A timber laid on the ground to support a floor joist.

Span—The distance between the bearings of a timber or arch.

Specifications—The written or printed directions regarding the details of a building or other construction.

Splice—Joining of two similar members in a straight line.

Stringer—A long horizontal timber in a structure supporting a floor.

Square—A tool used by mechanics to obtain accuracy; a term applied to a surface including 100 square feet.

Stairs, box—Those built between walls, and usually with no support except the wall strings.

Standing finish—Term applied to the finish of the openings and the base, and all other finish work necessary for the inside.

Stucco—A fine plaster used for interior decoration and fine work; also for rough outside wall coverings.

Stud—An upright beam in the framework of a building.

Studding—The framework of a partition or the wall of a house; usually referred to as 2 by 4's.

Subfloor—A wood floor which is laid over the floor joists and on which the finished floor is laid.

Threshold—The beveled piece over which the door swings; sometimes called a carpet strip.

Timber—Lumber with cross-section over 4 by 6 inches, such as posts, sills, and girders.

Tie beam (collar beam)—A beam so situated that it ties the principal rafters of a roof together and prevents them from thrusting the plate out of line.

Tin shingle—A small piece of tin used in flashing and repairing a shingle roof.

To the weather—A term applied to the projecting of shingles or siding beyond the course above.

Tread—The horizontal part of a step.

Trim—A term sometimes applied to outside or interior finished woodwork and the finish around openings.

Trimmer—The beam or floor joist into which a header is framed.

Trimming—Putting the inside and outside finish and hardware upon a building.

Truss—Structural framework of triangular units for supporting loads over long spans.

Valleys—The internal angle formed by the two slopes of a roof.

Verge boards—The boards which serve as the eaves finish on the gable end of a building.

Vestibule—An entrance to a house; usually inclosed.

Wainscoting—Matched boarding or panel work covering the lower portion of a wall.

Wale—A horizontal beam.

Wash—The slant upon a sill, capping, etc., to allow the water to run off easily.

Water table—The finish at the bottom of a house which carries the water away from the foundation.

Wind ("i" pronounced as in kind)—A term used to surface of a board when twisted (winding) or upon two diagonally opposite corners, if laid u flat surface.

Wooden brick—Piece of seasoned wood, made t and laid where it is necessary to provide a masonry walls.

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For explanation of abbreviations use, see AR 320–50.

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